ONTARIO POWER AUTHORITY

5

# Supply Mix Submissions and Presentations

Volume 5 – December 2005

Ontario Power Authority

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# Supply Mix Submissions and Presentations (Web only)

## Volume 5 – December 2005

Volume 5 contains the over 185 submissions and 21 presentations that provided input in the development of OPAs supply mix advice to the Minister of Energy. Submissions were received from individuals, companies, groups and organizations and were discussed in Part 2-3 of the Supply Mix Advice Report. Because in some cases, several parties submitted joint submissions, single parties submitted multiple submissions, or others requested that their advice not be posted, the submissions and presentations listed below may not match exactly with the list provided in Part 2-3.

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# Supply Mix Submissions and Presentations (Web only)

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Good afternoon,

As part of your public consultation process, I would like to participate by making several simple recommendations.

Simply, I strongly urge the adoption of significant policies aimed at a concerted conservation effort across the province, tied in with a large expansion of renewable power production potential (from a variety of sources, small-scall wind, cogeneration, landfill gas - diversification lends additional appeal).

I believe it is entirely impossible that such a committment will yield upwards of 60% of Ontario's power needs from renewables, when including realized conservation efforts, by 2020.

The net benefits to adopting serious efforts in these two categories concurrently will be varied and wide-spread, including large improvements in public health simply through the elimination of coal/gas power sources, while reducing long-term risks associated with phasing out nuclear power, which has clearly demonstrated itself to be far costlier than other alternatives such as conservation and renewables.

Further, in analyzing the options available to you in developing power scenarios for the province of Ontario, please take into consideration the impacts of your decisions on the great good of society, including public financial costs, pollution impacts (ranging from particulate matter to GHGs), public health impacts and associated costs. There are solid economic evaluations of the true costs associated with various power production regimes, and I urge you to use all methods of analysis and include these associated costs in your long-term planning.

Thank you

Aiden Abram

I believe there is potential for small customers to generate a substantial portion of their electricity usage through solar and small wind turbines. This is especially true for customers in rural areas. The high cost of installing solar panels and small wind turbines is slowing growth in this area at the current time.

I would recommend that the OPA undertake an analysis of the potential benefits of residential/small commercial/farm generation using solar and wind turbines (combined with the net metering initiative from the government) as compared to the costs and perhaps recommend to the government initiatives such as those passed by Governor Pataki in New York State last week (exempts solar energy equipment from state sales tax and provides a tax credit of up to 25% or $5,000 of the cost of heating, cooling and hot-water equipment that utilizes solar power).

I believe that this homemade environmentally friendly self generation could form an important part of the provinces overall supply mix.

Aiken & Associates

I say YES to whatever is best for all concerned, most definitely!!! Thank you, Wendy Aoki.

Hello,

Since the cost of fuel in general is rising, be it coal, oil, natural gas, electricity etc., the market conditions should be ripe for investment in renewable energy sources. I have been informed that wind power cost ~$1.2 million per megawatt. I'm not sure how much a megawatt is in real terms of power availability but wind seems to be the logical choice. There is also to potential of Hydrogen power generation. I have no idea what it would entail however this seems to be the cleanest way to generate electricity in the conventional way.

I feel that it would also be advantageous to over home owners rebates of some sort to create more fuel efficient homes. Some scale should be derived to gauge the potential and real energy savings and rebate accordingly.

I'm sure these ideas are not new but maybe I am part of a larger group indicating the same things. I wish all of you the best of luck in your endeavour to complete the task laid out before you.

Sincerely,

Richard Arsic

# Recommendations for Future Supply Mix

Association of Major Power Consumers in Ontario
Submission to the Ontario Power Authority

August 24, 2005

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# Executive Summary

AMPCO represents many of the largest power consumers in Ontario. The mix of fuel types and generation technologies supplying power to Ontario electricity consumers is the single biggest determinant of power costs.

AMPCO members face intense global competition and the low electricity cost advantage they once had has vanished. The process of demand destruction has started in Ontario. Recent announcements of plant and mill closures are a direct result of high and rising energy prices. Our concern is clear and urgent.

AMPCO believes the optimal supply mix outcome for Ontario is a diversified supply mix, with each available option deployed to its best advantage. This would include diversity of primary energy sources and also take advantage of opportunities for cogeneration, combined heat and power, demand response and distributed generation.

We are very concerned that current electricity policies are moving Ontario towards greatly increased reliance on natural gas for its electricity supply. We believe this is a dangerous direction for Ontario.

AMPCO does not support the premature retirement of Ontario's thermal generating plants. While the policy offers some environmental benefits, on balance we do not believe this policy is in the best interest of Ontario at the present time. Similar environmental benefits could be obtained by improving emissions controls on these facilities at a relatively low cost. This would provide for competitively priced electricity while making significant gains in environmental performance.

AMPCO supports well-planned conservation and demand management programs with measurable benefits. However, we caution that, in the absence of significant price signals, expectations of reversing demand growth are not supported by experience in other jurisdictions.

We offer some principles we believe the OPA should consider in its analysis of planning approaches and methodologies.

AMPCO is prepared to assist the Ontario Power Authority in its work.

# 1. Introduction

AMPCO appreciates the opportunity to provide input to the development of an Integrated Power System Plan for Ontario. AMPCO's 70 member companies consume about 20 percent of the electrical energy produced in Ontario. AMPCO represents the mining, refining, cement, steel, forest products, petrochemical, automotive and general manufacturing sectors. Our members provide direct employment for over 100,000 people and indirect employment for another 300,000. AMPCO companies generally pay wages well above the Ontario average, making their contribution to Ontario's economy all the more important.

Energy costs (electricity and gas) are a large percentage of the members' operating costs, in some cases second only to raw materials in importance.

Many AMPCO member companies operate globally so Ontario competes within these companies for production and investment resources. As electricity is a major component of our members' cost of production, electricity costs are a significant factor in decisions on new or sustaining investments. A long-term outlook for secure, competitively priced electricity is of vital importance in attracting investment to Ontario.

Many AMPCO members are also large users of natural gas. The projected increase in gas fuelled generation projects in Ontario raises concerns that decisions on fuel supply for electricity may affect the price and availability of natural gas. For this reason, our submission pays particular attention to the use of natural gas for electricity generation in Ontario.

AMPCO's member companies have a strong stake in the long-term security and cost of electricity in Ontario and Ontario in turn depends on the health of the industries AMPCO represents. We view supply mix as the single most important determinant of both electricity price and security.

This submission provides AMPCO's views on four areas relating to OPA's supply mix study: selection criteria, specific supply and demand technologies, study methodologies and the role of major power consumers in meeting Ontario's energy supply needs.

# 2. Supply Mix – Selection Criteria

The first step in developing any optimized solution is to determine the criteria that must be considered and the weighting each should receive. Below is a brief description of the factors AMPCO sees as important in determining a successful supply mix. We have included a brief discussion around each:

## 2.1Competitive Pricing

As noted above, the cost of electricity is critical for AMPCO members. Many of their original investments in Ontario were based in large part on Ontario's low electricity prices. Even resource-based operations such as forest products, mining and refining are highly sensitive to electricity cost. Today, this competitive advantage has been lost and electrical energy costs are now a competitive disadvantage for Ontario. Further deterioration will result in a lack of new or replacement investment, and reduce the competitiveness of our industries to the point that some existing operations will close. This process is already evident in the electrochemical and forest products sectors, but others are feeling the pressure as well.
In contrast, the primary competing jurisdictions for many of our industries are in the US, where the DOE is projecting stable electricity prices through to 2025.

In a fully regulated market, customers are typically charged the average cost of generation over time. In Ontario's market, as we understand it will evolve over time, some generation assets are to be regulated while others will continue to recover revenues from the IESO-administered wholesale market. This means that customers will face a combination of average costs—for regulated generation—and energy

prices based on marginal cost as determined in the wholesale market. In this context, the replacement of intermediate coal-fired generation with gas-fired generation carries with it the implications for significantly higher wholesale market prices based on the amount of time that gas will replace coal as the marginal generation fuel in Ontario. It is critical that the OPA's recommendations recognize this phenomenon and its impact on customers.

Plainly stated, Ontario industry cannot afford a supply mix that is significantly more expensive than that of competing jurisdictions.

## 2.2 Price Volatility

Not all volatility is bad. AMPCO members are capable of and accustomed to managing risks and responding to shifting fundamentals in the markets in which we operate. Our concern in Ontario's electricity market is where volatility occurs that does not seem to be based on fundamentals or is difficult or impossible to predict and manage. We do not support a fuel mix strategy that is focused on eliminating short-term volatility per se, as being likely to be unduly expensive over the long term. We are concerned with volatility that results from structural deficiencies in the market and market rules that make wholesale prices unduly sensitive and therefore excessively volatile in relation to fundamental risk and cost drivers.

The type of price instability that concerns AMPCO most is volatility that cannot be predicted or managed. For example, if a fuel source is consistently on the margin and the cost of generation is sensitive to the spot price of the fuel, this would create a level of price uncertainty that would make it very difficult for plants to enter price commitments or assess potential new facility investments. Companies can mitigate volatility risk with hedging strategies, but these bring their own cost and business risk issues.

## 2.3 Environmental Performance

AMPCO members strive to be good corporate citizens on behalf of their owners, employees and customers. They have made large investments to improve the environmental performance of their operations and continue to do so. This includes not only working to reduce emissions and other impacts, but also to increasing the energy efficiency of their processes and products.

It is natural that AMPCO believes a sound electricity supply strategy must also meet environmental performance objectives. Even in a time of decreasing energy intensity, total electrical production will grow with the economy and population. To protect the environment, the environmental impact per unit of electrical energy produced will need to decrease steadily.

With their experience in environmental performance, AMPCO members are aware that the best approach is to develop performance targets and then let companies meet them in whatever way that works best. AMPCO does not support policy that pre-selects specific technologies.
AMPCO believes that one criterion for a successful supply mix strategy must be that it produces an improvement in per-unit environmental performance over time and an absolute reduction in environmental impacts over the planning period. The calculation should include the effect of any scenario that would result in significant

imports of electricity, as these will often come from coal-fired plants with limited emission controls.

## 2.4 Economic Impact

AMPCO companies have a natural interest in the strength of the Canadian and Ontario economies. Not only is the Ontario economy dependent on the health of our industries, the reverse is also true.

Whatever supply mix Ontario uses; the impact on the Ontario economy will be large. Impacts will be determined by the technologies chosen, the supply contracting arrangements made (if any) and the ownership models selected.
From a narrow cost-minimizing perspective, a customer ought to be indifferent to where electricity is generated and how, so long as he is assured of the lowest possible price. However, AMPCO's view is informed by the broader context of the communities in which we operate. This is why, all other things being equal, we would favour a supply mix that uses the maximum of equipment and energy sources from Ontario, creating jobs and opportunity in the home market. We would be concerned if supply decisions generated large cash flows and wealth transfers out of the Ontario economy.

While AMPCO recognizes that using the electrical supply of Ontario as an instrument of economic or industrial policy is not within the scope of the OPA, we do believe the relative economic effects associated with different supply technology choices should be examined. In particular, evaluation of industrial cogeneration opportunities would be incomplete without consideration of non-electrical and economic benefits that would accrue to Ontarians.

## 2.5 System Reliability and Stability

The Ontario supply and delivery system currently performs with varying levels of reliability across the province. Some areas of the province receive much lower reliability than others, a consequence of system evolution and load density. Supply interruptions resulting from transmission or distribution failures cause considerable hardship for industrial consumers.

The decision by the government to phase out existing coal generation has the potential to decrease the stability and reliability of the system overall. At a minimum, system stability and reliability must not be allowed to deteriorate from current levels.

## 2.6 Price Stability and Security of Fuel Supply

When past supply strategies were developed, security of fuel supply at reasonable price was always a consideration. For fossil fuels and uranium, Ontario Hydro could negotiate long term contracts, thus hedging the cost and certainty of supply and enabling good projections for decision purposes.

This is no longer the case for fossil fuels in particular. Because OPG buys coal only on the spot market, the cost of coal generation has experienced increased volatility, as spot prices have responded to gas price volatility and a tightening market. Long-term coal contracts are available, but these are foreclosed by the government policy. AMPCO is particularly concerned with the increasing use of natural gas for generating electricity.

It is common knowledge that the North American market for natural gas is tight and getting tighter, as demand continues to grow and production from conventional sources is level or declining. Optimistic forecasts for reduced volatility, increased supply and future price reductions have not materialized and show no sign of doing so.

Over the past couple of years, price forecasts have been provided by the Canadian gas industry, the Ontario Clean Air Alliance and several consultants, which have been used as at least a partial basis for existing generation procurement policy and analysis. These have been consistently over-optimistic and reality has been worse than any of these projections, even worse than their "worst case" scenarios. Most optimistic forecasts for natural gas rely on several assumptions about new sources of supply. These include Canadian offshore gas, Mackenzie delta gas, coal bed gas and especially, LNG imports. For gas prices to stabilize at the lower levels predicted in these forecasts, all of these sources would need to develop as hoped, a scenario that could be described as more wishful thinking than realistic forecasting. Gas forecasts from Canada's continental shelf are not materializing as expected, the Mackenzie pipeline is still not a real project and coal bed methane is proving to be a technology that has issues of its own with regard to potential supply, price and environmental impact.

We expect LNG will play an increasing role in North American supply, but the complexities of development will make it difficult for LNG expansion to keep up with demand. Price forecasts for LNG at $US 4.50/MMBTU do not pass a reality check. The average 2004 price of LNG in Japan was $US 5.18 and had risen 64% since 1999, despite the existence of an established infrastructure, long term LNG supply contracts and a stagnant economy. Rapidly increasing global demand for LNG, combined with awareness by supplier countries of their bargaining position will ensure that LNG becomes steadily more expensive and difficult to get over time. As LNG makes natural gas more of a global commodity with steadily increasing demand, we can only expect prices to increase.

Moreover, LNG projects have long lead times, due not only to regulatory hurdles, but also to the need to purchase equipment and services that are in backlog. For example, an order placed today for an LNG tanker will not be filled for four years. Compounding the problem, LNG re-gasification capacity is being built faster than liquefaction plants. The result is a developing seller's market.

The foregoing discussion is not intended to suggest that natural gas should not be part of the Ontario energy supply mix. Rather, we wish to note our skepticism with overly optimistic projections for natural gas pricing. We do not doubt that supply will be available, but we are very skeptical that natural gas will ever again be priced low enough to justify its routine use for base load generation.

We see natural gas as a valuable, not cheap resource that will form a necessary but expensive component of the supply mix. As such, it should be deployed periodically to meet peak demands or in CHP (combined heat and power) applications, where its value can be realized. We firmly believe that natural gas should never be deployed as a base load fuel source in non-CHP generators. In fact, we suggest that all new

gas-fired combined cycle generation plants should be implemented with a significant CHP component to improve their cycle efficiency.
The third major fuel in Ontario, uranium does not seem to present significant price or availability issues. Fuel cost is a minor part of nuclear generating costs and Canada has large resources of uranium.

Ensuring that readily available and stably priced fuels meet Ontario's electricity requirements should be a key criterion for a supply mix strategy.

### 2.7 Fuel and Fuel Distribution Competition

Traditionally, the electric power system and large industry have used different fuels in Ontario. Ontario Hydro generally did not compete for supplies of thermal coal, uranium and hydroelectric potential, with the exception of some company-owned hydroelectric plants.

The introduction and rapid increase in the volume of gas fired generation in Ontario is changing this state of affairs, and the consequence is a number of negative secondary effects on many of the large industries the Ontario electricity system is intended to serve. Key concerns include:

- Supply interruptions to industrial customers on interruptible contracts could increase, as electrical generation requirements are given priority for pipeline capacity.
- Pipeline and storage capacity will become more expensive in general.
- Gas will become more expensive. Gas industry forecasts in early 2004 estimated that the replacement of Ontario's coal plants with gas-fired generation would result in an average 4% increase in the price of gas. This was before the market tightened, so it is realistic to expect a larger effect in the future.
- Gas distribution, pipeline and storage facilities will need to be increased to accommodate the increase in gas consumption related to electricity generation and industrial customers will be forced to pay for much of the expansion.
- The irregular nature of consumption of gas for electric power generation will increase the price volatility of natural gas in Ontario.

## 3. Fuels and Generation Technologies

A diverse mix of economically viable technologies and fuels best serves Ontario. We believe diversification of supply brings these important benefits:

- Security of supply risk is minimized. If one fuel becomes unavailable or uneconomic to use, other sources can reduce reliance on it.
- Economic risk is hedged. If the mix of generation includes types with low fuel costs and high capital costs as well as those with low capital and high fuel costs, the best aspects of each can be leveraged.
- Technical risk is minimized. Utilizing different generation technologies reduces the chance that a single technical problem will compromise the whole system.
- Operating flexibility is maximized. A diverse generation portfolio offers the best opportunity to optimize such requirements as spinning reserve,

operating reserve, VAR compensation and so forth. For example, having several units available as operating reserve with fast ramp rates can reduce the need for larger, slower responding units to be kept ready.

- Environmental performance can be optimized. With a variety of sources available, the use of less reliable generation but clean sources such as wind power can be increased.

We note that in jurisdictions requiring significant amounts of non-hydroelectric generation, those with well-diversified generation sources tend to have lower and more stable prices. Jurisdictions that have followed single–fuel strategies, such as Florida and California have not been as fortunate. Following are AMPCO's views on the specific technologies that are currently available:

## 3.1Hydroelectric

AMPCO supports development of additional hydroelectric facilities where they are economic without subsidies and where their environmental effects are deemed acceptable.

While there may be a role for new hydroelectric power in Ontario, it seems that the available sites will be more suited to peaking, reserve and automatic generation control than for a large energy contribution.

With respect to the possibility of importing significant amounts of power from either Manitoba or Labrador under long-term contracts, we believe these options should be evaluated on their merits. These projects would appear to require large investments in both generation and transmission facilities and their economic viability as supply for Ontario is unclear.

## 3.2 Wind Power

AMPCO believes wind power has potential to become an economic and environmentally benign source of electrical energy, particularly when it can reduce the use of expensive natural gas. By using wind power in place of fossil fuels, it can contribute to our energy security and help meet environmental performance targets. As such, it merits encouragement through policy means and other instruments. With its inability to be dispatched reliably, especially during summer peak periods, wind power may be best suited for select applications (e.g., those where unpredictable availability is not a problem or high cost grid connections can be avoided) to help supplement Ontario's energy needs, but not as a significant contributor to meeting demand or reserve requirements.

However, it is also clear that wind power technology is not yet sufficiently mature or economic to play a large role in Ontario's energy supply. Experience in other jurisdictions such as Quebec has highlighted issues with equipment reliability, lower than forecast energy output and overall cost. Even with effective subsidies of 1 cent/kWh, wind remains one of the highest cost energy sources available. However, its progress in technical and economic improvement suggests that a larger contribution could be part of the future supply.

## 3.3Conventional Coal Generation

The current policy to retire from service the existing coal-fired generating stations at Lambton, Nanticoke, Atikokan and Thunder Bay is the single biggest factor causing upward pressure on rates and increasing risks in Ontario's electricity market. To mitigate price risks and sustain an electricity rate environment that will encourage continued investment in Ontario's industrial sector, AMPCO strongly feels the existing coal-fired plants should be kept in operation.

As a source of electrical energy with characteristics of fuel cost, capital cost and price stability that are intermediate between gas and hydroelectric, coal power provides the opportunity to provide a critical part of a diverse supply portfolio. We do support, however, an investment in reducing emissions from these facilities. Our analysis suggests that the environmental performance of these facilities can be dramatically improved for a relatively modest investment.

## 3.4 Integrated Coal Gasification – Combined Cycle Turbines

This technology promises to reduce coal emissions further, at additional capital and operating cost.

From AMPCO's perspective, the prospects for ICGCC technology appear uncertain in the next five or ten years. However, the longer term outlook for steadily increasing gas and oil prices vs. very large domestic coal reserves suggest that clean coal technologies will form key part of the electricity supply in North America. The recent US energy bill, with US$1.8 Billion for clean coal development, reinforces that coal will continue as a major contributor to the US energy supply.

We recommend that, at a minimum, OPG be directed to maintain ownership of its current coal generating plant sites, along with as much of the coal handling and management infrastructure as can reasonably be kept from deterioration.

## 3.5 Gas- Fired Coal Plants

We are aware the government has considered firing one or more of the existing coal fired units (nominally Thunder Bay or Lambton) with natural gas instead of coal. Given the high price of natural gas and the lower thermal efficiency of these plants, AMPCO feels this option to be unwise. If these units are needed, they should be allowed to continue burning coal and their environmental performance enhanced with available cleaner coal technologies. From AMPCO's perspective, there is no logical reason to fire coal units with expensive natural gas.

## 3.6 Simple Cycle Gas Turbines

We believe this technology should be considered for a small part of Ontario's supply mix, for very occasional peaking requirements. While relatively more polluting and less efficient than combined cycle plants, simple cycle peaking units can, if used sparingly, provide specific capabilities at low capital cost.

## 3.7 Combined Cycle Gas Turbines (CCGT)

This technology also has a place in Ontario's supply mix, as it can combine high thermal efficiency, low emissions, fast ramp rates and low capital cost. However, the high and rising cost of natural gas suggest it should not be allowed to become the

dominant price setting generation source. CCGT make most sense as a generating source when it is deployed in a CHP configuration.

There are several additional issues that arise when large gas fired plants are brought into the system. If they are located at a distance from storage facilities (i.e., outside the Sarnia area), they need to ensure availability of gas for the time they plan to generate. The day-ahead market for gas does not fit well with the use of natural gas for peaking power and the need for a gas plant to reserve pipeline capacity can lead to other gas users, such as industries on interruptible contracts, to be denied supply. It also does not fit with the current two-hour dispatch schedule, which is important for efficient operation of the electricity market design.

There are of course, technical solutions for these issues, but they require significant new investments in the gas distribution system. Such investments must be paid for and this cost should form part of the OPA's analysis. Suggestions that these costs would not impact the cost of generation should be seen as being either disingenuous or an indication of intent to cross- subsidize the costs from other gas customers.

### 3.8 Nuclear – Refurbishment

As a matter of principle, assets should be kept in service for as long as it is economically practical and safe to do so. This includes Ontario's nuclear fleet, both in OPG and Bruce Nuclear.

Unfortunately, we do not know the full extent of the refurbishment opportunity that exists, as it tends to become apparent only when units are removed from service for assessment. For example, Bruce A Unit 3 is scheduled for removal from service in 2009, but it may turn out to be economic to refurbish it at that time.

### 3.9 New Nuclear

In any scenario that includes reasonable economic growth in Ontario; minimum demand will continue to grow. Moreover, demand response and demand management initiatives, if successful, should have the effect of raising minimum demand over time. By shifting energy use from periods of peak demand to valley periods, the proportion of base load generation will grow. This is a natural fit with the characteristics of nuclear power.

The IESO's recent 10-year outlook suggests that Ontario may need an additional 4,000MW of base load generation by 2015. Looking further out, there may be a place for at least that much again before the end of the OPA planning horizon.
While AMPCO believes advanced coal fired generation technologies could be meeting at least part of this load, new nuclear capacity should also be considered.

Nuclear power has a poor reputation on Ontario, because of the Darlington costs and the poor operating performance of OPG and Ontario Hydro. On the other hand, nuclear power has succeeded in other jurisdictions, with plants in the United States steadily improving. Recent Atomic Energy of Canada Limited (AECL) projects overseas seem to be performing better than those here in Ontario. AECL's recent willingness to provide guarantees for project outcomes in the Point Lepreu refurbishment is also encouraging. We also note the performance of Bruce Nuclear and improvements by OPG in operating Pickering and Darlington.

Considering the above, AMPCO believes new nuclear generating plants may have a role in Ontario's long-term base load supply mix. This is likely to require some level of government support.

### 3.10 Photovoltaic Power

AMPCO sees no value in grid connected photovoltaic power for Ontario. We note the very heavy subsidies in Europe and California, which amount to multiples of the price of conventionally generated electricity. This does not seem a wise use of limited resources. Considering the slow progress in reducing unit costs or increasing efficiency, this does not seem to be a technology that will be competitive on the grid in the near to mid term. Moreover, Ontario is not suited geographically or climatically to be an early adopter for solar technology.

### 3.11 Distributed Generation/Distributed Resources

For purposes of this discussion, we regard DG/DR as any generation source hat can be connected to the LV or distribution systems, i.e., with a nameplate capacity below 30MW.

Small generating units using conventional energy sources such as natural gas or water are at an inherent unit cost disadvantage versus larger units that can connect to the transmission system. This will likely slow the advance of this type of DG, except in situations where specific local conditions make a project viable. However, there are a number of situations where DG/DR may be both economic and environmentally attractive to pursue, such as:

- Projects that take advantage of a unique local energy supply that would otherwise be wasted or even polluting, such as landfill gas, wood waste, manure, small hydro, small wind, etc.
- Combined heat and power projects, such as energy centers in large malls or apartment complexes.
- Applications where the total cost of generation and transmission will be lower than if the DG plant is not built. For example, generation in remote communities or in areas where the distribution system on its own cannot assure adequate reliability and local generation could enable "islanding" during system line outages.

Distributed Resources refers to those supply resources that exist and could be accessed during specific, uncommon situations. Often, these take the form of backup generation capacity owned by private enterprise, such as in data centers, hospitals, etc. In total, these represent a significant potential resource that could be available under specific conditions to reduce peak transmission loads or provide needed energy during a system emergency. Because much of this resource is diesel powered, its use would likely be restricted for environmental reasons. However, existing private supply resources can contribute meaningfully to Ontario's energy supply and this opportunity should be explored.

### 3.12 Cogeneration

Industrial customers use about a third of all the power generated in Ontario and several large commercial customers also have substantial loads.

Many of these loads are natural candidates for cogeneration, especially where the customer can leverage CHP opportunities. In such cases, the potential for Ontario is to increase supply, reduce demand, reduce transmission requirements, improve overall energy efficiency and reduce emissions.

In some cases, the cogeneration fuel is a byproduct of the manufacturing process, further increasing the overall benefit and reducing dependence on fossil fuels. Air pollution can be reduced by using byproducts that would other wise be flared off, while increasing energy supply.

AMPCO strongly supports the development of energy procurement policies that recognize the value and advantages of cogeneration.

# 4. Planning Methodologies

Rather than propose specific methodologies, we offer the following principles as guidelines for the development and implementation of planning methods by the OPA.

## 4.1Flexibility vs. Decision

"It's a bad plan that can't be changed" – Pubilius Syrus

This quote is a good comment on the need for any plan to be adaptable to changing circumstances. However, many projects needed to provide long-term energy security have long lead times and long asset lives. Many solutions that can be implemented fairly quickly also have long asset lives, but are often characterized by high energy cost and price volatility.

For example, a decision to contract with Manitoba for power from Conawapa will not result in delivery of electricity from the project for at least twelve years and perhaps fifteen. Similarly, a new nuclear plant needs at least eight years from the decision to commit until it is on-line.

AMPCO would like the OPA report to clearly identify the points in time when key decisions have to be made on future supply, particularly with respect to the construction of new base load generation.

## 4.2 Public vs. Private Power

AMPCO prefers private involvement in the development of energy assets. However, we are also aware that there may be cases where government involvement in financing and other matters may be needed to secure the lowest long term price of energy.
We recommend the OPA, when evaluating various supply scenarios, include both public and merchant plant scenarios for those technologies where costs are sensitive to this issue (e.g., nuclear, large hydroelectric).

## 4.3 Externalities

We have reviewed recent studies that claim to quantify health and environment costs and benefits associated with different generation technologies and fuels. In our view, such studies are only as good as the underlying research or data. While we support an analytical and quantitative approach to formulating policy—and in particular to address the important issues associated with supply mix—we would caution against

the temptation to reach for simple conclusions. At a minimum, any analysis must account for the impact of higher electricity prices.

### 4.4 Subsidies & Related Instruments

As much as possible, the structure of Ontario's electricity supply should be determined by market forces and not by overt policy preference for specific technologies. In particular, AMPCO opposes the use of subsidies to specific market participants by means of guaranteed prices or returns on investment.

Other jurisdictions such as Germany, Denmark and Spain are routinely held up as success stories for renewable generation. However, the prices being forced on customers for electricity from renewable power projects in these countries range from about double the rate for conventional sources to several multiples of the conventional electricity cost. If implemented in Ontario, such policies would amount to a forced transfer of wealth from consumers to producers. In an economy as energy intensive as Ontario's, this would be much more damaging than in Germany or California.

The proponents of subsidies for renewable energy are currently promoting instruments called standard offer contracts, feeder prices and advanced renewable tariffs. All of these amount to guaranteed high prices on long term contracts (typically 20 years), some with incentives that actually increase for less economic proposals. These perverse features are antithetical to the market design Ontario has been painfully developing, where the most economically efficient producers experience the greatest success.

We are aware that the federal government has subsidies in place to promote wind power and other renewables. This activity is beyond the scope of this review, but we note that, at the least, it is financed by all taxpayers and not burdened directly on Ontario electricity customers.

It also appears that the nuclear industry is promoting two potential forms of subsidy. One would involve a premium price for the new ACR (Advanced CANDU Reactor) and the other involves potential government backed financing for new nuclear. Since AECL is a federal company, we believe any premium required to construct the first ACR should be borne either by AECL directly, by its owner or its contractors.

With respect to government financial guarantees for a new CANDU project, we believe this needs to be examined carefully, to determine if the risk is properly balanced by the opportunity for lower costs.

### 4.5 Demand Management Uncertainty

The Ministry of Energy has set ambitious targets, to reduce peak demand while the economy and population continue to grow. While the long-term trend is one of declining energy intensity in the economy, we are not aware of any healthy economy that has effectively reversed demand growth.

For the period 1980-2001, the G8 countries, including Canada, reduced their energy intensity an average of 1.6% a year, while growing their economies by 2.6% per year in the same period. The net result was that energy demand grew on average by

1% a year and continues to do so. Canada, with the highest energy intensity of the G8, followed this same trend.

With the above in mind, we recommend the OPA take a conservative planning approach that assumes a slower growth in peak demand relative to economic and energy growth, with the flexibility to defer peaking and intermediate capacity should DM program effectiveness be greater.

### 4.6 Natural Gas Price and Availability

AMPCO's concerns about natural gas as a fuel for base load generation were expressed earlier in this submission. However, we would also like to comment specifically on the use of gas pricing assumptions.

In studies we have seen, estimates of future prices for natural gas have been consistently low. For example, a recent analysis of the full cost of different generation scenarios by DSS Consultants for the Ministry of Energy relied on a 2007 price of natural gas at $CAN 6.50/MMBTU, with 0.7% annual escalation. Prices at Dawn have not been that low since 2003 (gas currently exceeds $US 8.00/MMBTU), and annual price escalation has been in double digits.

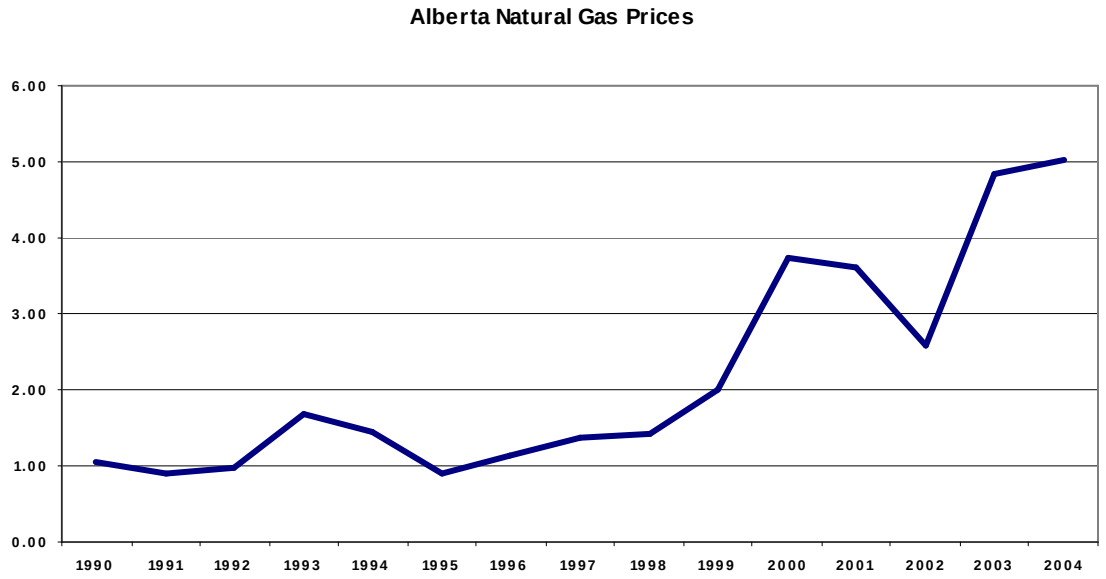


Fig 1: Average annual Alberta natural gas prices 1990-2004 in $US/MMBTU.
Since year-end 2004, prices have continued to rise.
(BP statistical Review of World Energy)

It is not credible to suggest that natural gas prices will decline in the near or medium term.

## 5. Where AMPCO can help

AMPCO's members are the largest power consumers in Ontario. As such, they are well placed and willing to be part of the solution to Ontario's energy supply requirements.

## 5.1 Energy Conservation and Demand Management

Many AMPCO members have significant remaining opportunity to curtail peak demand and energy use. Generally, these opportunities are more economic to achieve and more reliably measured than those available in the residential sector. However, these projects often fail internal requirements for investment due to ROI requirements that are necessarily more aggressive than those the utility sector or government would use.

Careful development of conservation and demand management incentives for large users, together with the flexibility to tailor them to specific situations would result in significant improvement to our industrial energy efficiency.

## 5.2 Demand Response

Many AMPCO members can manage some of their electricity use on short-term intervals to reduce peak demand.

In theory, the market will produce adequate demand response to dynamically balance supply and demand. In practice, the existing market does not deliver the total benefit of demand response to the customer with the ability to respond.
It is logical then, to consider payment for predictable amounts of demand response to customers that are willing to commit to these arrangements.
Because a demand response arrangement with a customer can be quickly reversed, the IESO and planners in general hesitate to include it as a reliable supply option. However, we believe this uncertainty can be mitigated through appropriate contractual arrangements. The key will be flexibility in tailoring arrangements to match the particulars of large user's situations to specific system needs. For example, many industries that cannot provide demand response on a five minute basis can provide significant response on longer time scales, similar to those required to bring on a cold thermal unit on the supply side.

## 5.3 Dispatchable Load

Currently, Ontario has about 500MW of dispatchable load in place and the IESO has plans for an additional 500MW. As large users, AMPCO members can provide additional opportunities for dispatchable load and thus reduce the need for additional generation.

## 5.4 Cogeneration

Several AMPCO members already generate significant amounts of power on their own and some of this is made available to the grid. There is a significant opportunity for more cogeneration projects, but this would require mechanisms that bring to the developer more of the benefits that are realized by the customer population as a whole when these projects go ahead. For example, cogeneration projects typically improve system stability, release transmission capacity and reduce line losses. Cogeneration should be near the top of the list in terms of its attractiveness as a source of energy for Ontario, since these projects tend to be CHP, provide benefits throughout the system and represent commitments by users to continued operation in Ontario. Again, there may be some contractual and market rule adjustments needed to improve the attractiveness of cogeneration for industries. Recent moves by the OEB in its TSC revisions are a step in this direction, but much more can be done.

## 6. Next Steps

AMPCO has a demand response proposal in draft form and is prepared to share this work with the OPA as a basis from which to develop a practical industrial DR program.

Association of Municipalities of Ontario

***OFFICE OF THE PRESIDENT***

August 25, 2005

**Sent by e-mail to:**
**supplymixsubmissions@powerauthority.on.ca**

Jan Carr
Chief Executive Officer
Ontario Power Authority
Supply Mix Submissions
175 Bloor St. E., North Tower, Ste 606
Toronto ON M4W 3R8

Dear Mr. Carr:

**Re: Supply Mix Submissions**

I am writing to provide you with input regarding your request for submissions on "supply mix". Municipal governments are key partners in this discussion as we are not only leaders in energy conservation, we are also major consumers of energy and many of us are shareholders of Local Distribution Companies (LDCs).

We welcome your request for comments and would like to share our thoughts specifically on energy conservation and alternative energy sources. From a conservation perspective, municipalities are essential to any strategy. As shareholders of LDCs we are directly involved in demand side management (DSM) and conservation demand management (CDM) initiatives. Since LDCs deliver many conservation projects, we interact with residents and businesses on conservation measures and can work with you to inform you of successes and challenges in implementing your vision.

AMO as an association is also working towards conservation. We have recently established a Task Force on Energy Conservation that not only plans to work with the government on recommendations and strategies, but will also share best practices with our members. Another initiative we are pursuing is a pilot project on conservation management. The project will bring together 14 municipalities to conduct energy audits, increase information and develop best practices to reduce energy consumption.

Regarding your request for recommendations about new renewable energy capacity, we invite you to speak with us regarding the potential that exists from energy from waste. Great potential exists to address energy, waste and source water protection through exploring energy from waste initiatives. With the threat of the US border closing to Ontario waste, we will face a capacity issue in the province to deal with garbage. Manure management is also key to source water protection. We feel that technology has evolved to such a point where there are many viable options that need to be explored to address these issues. These include the exploration of small-scale projects such as bio-digesters to the creation of energy from processing garbage, to name a few.

AMO's Task Force on Energy Conservation and its Task Force on Waste Management will be working on these issues in more detail. As partners, we will share our recommendations and strategies with you so we can address these issues together.

Yours truly,

Roger Anderson
President

cc: Hon. Dwight Duncan, Minister of Energy
Hon. John Gerretsen, Minister of Municipal Affairs and Housing
Hon. Laurel Broten, Minister of Environment
Hon. Leona Dombrowsky, Minister of Agriculture, Food and Rural Affairs

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# Re-thinking the Coal Decision

## Air quality and power generation investment in Ontario

A Report from AWS Consulting

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# Summary: coal-fired power generation, air quality, and climate change

COAL-FIRED ELECTRICITY GENERATION IS REGULARLY SINGLED OUT in opinion-leading circles as the primary cause of poor air quality in Ontario. This is the basis for the Ontario government's plan to phase out coal generation in this province. But blaming coal generation for this alleged problem is not only incorrect, it also ignores other, more significant sources of air pollution. Coal does produce emissions of two of the five major pollutants, nitrogen and sulphur compounds. But it produces comparatively insignificant quantities of the other three pollutant groups: carbon monoxide, particulates, and volatile organic compounds.

In any case, eliminating coal generation altogether seems a drastic way to eliminate nitrogen and sulphur emissions. Coal is an inexpensive fossil fuel—much less expensive than natural gas. Nitrogen and sulphur emissions from coal combustion are effectively reduced using proven, commercially available technology. This technology is in use at hundreds of coal-fired units around the world,[1] including six of the fourteen units in Ontario.

Though only partially implemented in this province, this technology has produced impressive results. Nitrogen and sulphur emissions from the Ontario plants have dropped significantly, both in absolute and relative terms (for reductions at the Nanticoke plant, see Fig. 14 on page 30). This is part of the reason why amounts of airborne nitrogen and sulphur in Ontario have declined since the 1970s (see "Air quality: perception vs. fact" on page 11).

Opponents of coal generation have played down these reductions by misrepresenting reports on the performance of emission-reduction devices. By exploiting the confusion surrounding air pollution and greenhouse gases, anti-coal lobbyists have tried to mislead the public into believing that emission-reduction devices do not work.[2] At the same time, coal's opponents exaggerate the impact of coal emissions on public health, while playing down bigger sources of pollution (see "Criteria Air Contaminants" on page 21). This is an attempt to frighten people into accepting the huge cost of closing the coal plants and switching to gas.

The government of Ontario has also claimed that emission-reduction devices are ineffective. This is surprising, because in its overall air quality strategy the government encourages other industrial nitrogen and sulphur emitters in Ontario to adopt similar technology. It even sets out guidelines for selecting this technology (see Footnote 31 on page 30).

## Smart leadership on air quality and climate change

The government's contradictory position—claiming on one hand that emission-reduction devices do not work in electricity generation, while on the other hand encouraging their use in other emitting industries—needs to be resolved. Ontario will soon be in negotiations with neighboring U.S. states on air quality issues. U.S. federal and state authorities will not force American utilities to close their own coal plants for environmental reasons. Rather, they

1. The U.S. EPA estimates that de-sulphurization devices were in use at 668 coal generating units around the world in 1998, and that nitrogen-removal were in use at 216 units in Europe and many more in the U.S. in 1997. (Source: for sulphur, "Controlling $SO_2$ emissions: a review of technologies," EPA/600/R/-00/093, November 2000; for nitrogen, "Performance of selective catalytic reduction on coal-fired steam generating units," EPA Acid Rain Program, June 1997.)
2. See "The difference between air pollution and greenhouse gas," beginning on page 19.

will more likely choose the regulatory path. The chief feature of this will be to require U.S. utilities to comply with domestic and international clean-air agreements by adopting the "cleaner coal" approach: installing emission-reduction devices on more coal-fired units.

If Ontario does not adopt the cleaner coal approach, the result will be higher electricity costs in this province. This is because the only way to replace coal is with natural gas, which is far more expensive. As costs go up, the government will have less room to manoeuvre when it comes to implementing the Kyoto Treaty in the electricity sector. Successful Kyoto implementation in this sector depends entirely on the government's ability to add carbon-free generation to the provincial system while keeping electricity affordable. At present, the only viable large scale carbon-free source is nuclear power, and the cheapest fossil fuel is coal.

Recent history in Ontario proves the nuclear–coal combination can achieve major emission reductions. In 1994–1995, all units at the Darlington, Pickering, and Bruce nuclear stations were running at good capacity. There was far less need for baseload electricity from other sources, including coal. Because of this, emissions from coal generation were much lower then than at any time since the 1980s. Ontario's electricity was plentiful, reliable, and affordable—and nearly 90 percent carbon free. (See Fig. 17 on page 34.)

This situation could easily be achieved once again, provided the government approves nuclear refurbishment at the Bruce station and new nuclear construction at the Pickering station. Carbon, nitrogen, and sulphur emissions could be halved simply by decreasing coal generation and increasing nuclear generation. This would make Ontario's electricity sector totally Kyoto compliant, while bringing the entire province within 8 million tonnes of compliance.

The government could then further reduce nitrogen and sulphur from the already-reduced coal emissions simply by completing the cleaner coal implementation and installing emission controls on the remaining eight coal-fired units.

To its credit, the government recognizes the central role nuclear power must play in stabilizing the province's electricity supply while meeting its Kyoto and clean air commitments. But the government's coal shut-down decision threatens to undo this progress. Keeping coal in the provincial generation mix will keep electricity affordable, and affordable electricity is the basis for a healthy economy. Successful Kyoto implementation requires a healthy economy.

The government's coal shut-down policy appears to be based on a flawed assessment of the air quality issue. Ironically, in addition to the huge cost of switching to natural gas, another important implication of the coal shut down is air quality itself. As you will see in the sections below, other Ontario emitters, as well as other sources, contribute greater quantities of nitrogen and sulphur. Moreover, other sources contribute far greater quantities of the other three major pollutants—carbon monoxide, particulates, and volatile organic compounds.

This means that a great deal of public money will be sunk into an enterprise that will leave the truly significant sources of pollution untouched.

SEE ALSO *Incorrect and exaggerated: the basis of the coal shut-down policy* ..... page 5
*Air quality: perception vs. fact* ..... page 11
*International sources of air pollution in Ontario* ..... page 15
*Types and sources of emissions originating in Ontario* ..... page 19
*Reducing CACs and GHGs* ..... page 29
*Ontario's influence on U.S. environmental policy* ..... page 37

# Incorrect and exaggerated: the basis of the coal shut-down policy

THE ONTARIO GOVERNMENT'S DECISION TO SHUT DOWN COAL was based on a series of incorrect analyses and exaggerated risk assessments. It appears the government made this decision, and is holding to it, out of a desire to mollify interest groups who base their arguments on these incorrect analyses and assessments.[3] Some of these groups take advantage of the public's perception that air quality is declining.

## Incorrect analyses

In addition to this, opponents of coal generation routinely exaggerate the impact that coal combustion has on our air, while downplaying other, larger sources of pollution. For example, even though motor vehicles produce far greater quantities of carbon monoxide, volatile organic compounds, and nitrogen oxides than coal generation does (see "Criteria Air Contaminants" on page 21), anti-coal lobbyists rarely mention motor vehicles as a source.[4]

Not only do motor vehicles produce more pollutants, they are also more localized sources of these pollutants. Motor vehicles operate in far closer proximity to people than Ontario's coal plants do. Automobile tail pipes are typically less than a metre from ground level. By any measure, emissions from motor vehicles represent a far greater threat to human health than coal plants operating hundreds of kilometres away from most large urban centres in Ontario.

This means that an expensive policy to shut down the province's coal plants will only leave other, larger sources of pollution unaddressed. Southern Ontario will still experience smog alerts and there will be little difference in the Air Quality Index ratings. In fact, there

3. The opinions of certain experts and interested advocates have played a major role in the current government's policymaking with respect to coal generation. Dr. Larry Erlick, former head of the Ontario Medical Association, said in March 2004, "Taking a step to deal with the pollution of Ontario's coal-fired plants is a step toward saving lives." William Kennedy, executive director of the Commission for Environmental Cooperation, said "Electric power plants are definitely the Number 1 polluter in North America" (June 2004). The home page of the Ontario Clean Air Alliance (OCAA), a pro-gas lobby group whose sole purpose is to eliminate Ontario's coal plants and replace them with natural gas generators, displays a prominent banner that reads "Dirty air, dirty coal, dirty power." In March 2004, Donna Cansfield, Liberal MPP from Etobicoke Centre and the Energy Minister's parliamentary assistant—who acknowledges the role the OCAA plays in helping her understand the electricity business—said "Closing the coal-fired generating stations will help save lives." These views have influenced the largest and most influential newspaper in Ontario, the *Toronto Star*. In June 2004, a *Star* article stated that "the single biggest polluter in all of Canada is the provincially owned Nanticoke coal fired power plant on Lake Erie."
4. The Ontario Clean Air Alliance is a good example of a lobbying organization that exaggerates the role of coal generation while ignoring much larger sources of pollution. The OCAA's web site contains ten times as many references to "coal" and "electricity" as to "car," "cars," "automobile," "transportation," "truck," or "vehicle" combined. This is in spite of the fact that in the year 2000, gasoline-powered cars and trucks produced nearly 228 times as much carbon monoxide and 623 times as much volatile organic compounds as all Ontario coal plants (see "Types and sources of emissions originating in Ontario," beginning on page 19). The OCAA also routinely misrepresents public data on coal-plant emissions; see "The difference between air pollution and greenhouse gas" on page 19.

will likely be more auto emissions, because the higher electricity prices that will result from eliminating coal will drive up the Toronto Transit Commission's subway operating costs—thereby forcing up rider fares and discouraging higher ridership. Greater use of public transit is a major pollution-reduction strategy.

Opponents of coal generation also ignore the fact that the public is well aware that motor vehicles are the primary source of pollution.[5] The government should take care not to interpret the appeals of the anti-coal lobby as being in step with general public opinion. While it may seem that the public tacitly approves of the coal shut down, it is likely that when the economic consequences of this policy become known, the public will wonder why so little was done about the biggest source of air pollution—especially when the government continues to issue smog alerts and advisories.[6]

In view of the great expense entailed in a wholesale switch to natural gas, the government owes it to its larger constituency to look beyond the exaggerated and self-interested claims of the anti-coal lobby and re-examine the coal decision.

## Is air quality really declining?

There certainly is a perception that air quality in Ontario has been declining.[7] However, public data show otherwise. The Ontario Ministry of the Environment says that the province's air quality has actually been continually improving since the 1970s (see below, beginning page 11). According to the government's most recent air quality report, Air Quality Index (AQI) sites across the province reported pollutant concentrations in the "very good" to "moderate" range 99 percent of the time in 2003.

The AQI sites reported concentrations in the "poor" category only one percent of the time in that year. Of these, the pollutants involved were ozone ($O_3$) and fine particulate matter ($PM_{2.5}$)—most likely, according to the government's report, due to precursor emissions originating in the U.S. None of the AQI sites reported concentrations in the "very poor" category at any time in 2003.

Of the five major pollutant groups, sources other than coal generation account for the overwhelming share of three—particulates, carbon monoxide, and volatile organic compounds (see "Types and sources of emissions originating in Ontario," beginning on page 19).

As mentioned, coal generation does produce significant quantities of the remaining two pollutant groups, nitrogen and sulphur. But there are two important things to keep in mind with respect to these two pollutants. First, as is the case with most other pollutants, ambient

5. Content analysis of Canadian newspapers since 2000 shows that the number of articles associating air pollution with motor vehicles is on average three times greater than those associating air pollution with electricity generation. (Source: Canadian Business and Current Affairs media database.) A recent article in the Toronto paper *Now* ("Miller clears the air," July 28–August 3 2005, pp. 18–19), lists 13 measures to cut smog. The first eleven are very specific measures to deal with emissions from motor vehicles; only the final two refer to electricity, and then only vaguely.
6. As of this date (August 24, 2005) there have been 60 days in 2005 on which Ontario's AQI reported "Moderate" or poorer air quality in downtown Toronto. Fifty of these days were after the coal-fired Lakeview Generating Station—supposedly the primary cause of smog in the Greater Toronto Area—was permanently closed. See http://www.airqualityontario.com/reports/aqisearch.cfm?stationid=31103&Submit=2005+History&startmonth=all.
7. In an opinion survey published on August 31, 2005, nearly two-fifths of respondents indicated they believe their health has been adversely affected by air pollution. Concern about air quality was highest in Ontario. See "Canadians Say Pollution is Making Them Sick and It's Getting Worse," Canada NewsWire, August 31, 2005.

air concentrations of nitrogen and sulphur have declined over the past three decades, as have the amounts emitted (see "Air quality: perception vs. fact" on page 11).[8]

Second, it is possible to reduce levels of these pollutants even further using commercially available emission control devices. In fact, the long-term declines in nitrogen and sulphur levels in Ontario's airshed are due, in part, to successful emission reduction efforts at Ontario coal plants. These efforts included installing emission control devices at two of Ontario's coal plants (see below, page 29).

These two plants—Nanticoke and Lambton—now generate more electricity but less nitrogen and sulphur. In the case of Nanticoke, see Fig. 14 on page 30. The Ontario government is now seeking to extend the use of these devices to other emitting industries, such as non-ferrous mining and smelting, steelmaking, and petroleum refining.

Still, most airborne nitrogen and sulphur continue to come from upwind U.S. states[9] and other Ontario sources.[10] For example, on-road vehicles are by far the biggest contributing source category of volatile organic compounds and nitrogen oxides. American and other Ontario sources account for greater proportions of nitrogen and sulphur emissions than coal generation does.

## Exaggerated risk assessments

In spite of the progress made in reducing pollution emissions and improving Ontario's air quality, the issue of air quality remains a matter of great public concern.

Coupled with some recent studies suggesting that increased mortality rates are due to elevated concentrations of certain air pollutants, this concern has led to renewed calls for dramatic action to curb air pollution. The government, in response to pressure from the anti-coal lobby, has used some of these studies' findings to justify closing Ontario's coal plants. It commissioned one study that even estimates the number of premature mortalities—660 per year—directly attributable to the Lambton and Nanticoke coal plants.[11]

Such "body count" analyses certainly make for dramatic news stories, and provide easy ammunition for opponents of coal generation. But the analysis artificially isolates certain constituents of coal emissions, exaggerates the roles they play in forming other pollutants, and then in turn exaggerates the resulting pollutants' roles in causing premature deaths.[12]

For example, the government-funded study focuses on two types of particulate matter (PM), nitrates and sulphates. This is because these are formed in the atmosphere by chemical reactions with precursor substances—in this case, sulphur oxides and nitrogen oxides, both of which are products of coal combustion. The study estimated the amounts of particle sulphates and nitrates resulting from these atmospheric chemical reactions, then added them to primary PM concentrations to arrive at total PM concentrations.[13]

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8. Average concentrations of nitrogen dioxide decreased by 26 percent between 1975 and 2003. Concentrations of sulphur dioxide decreased by 86 percent between 1971 and 2003. See "Air Quality in Ontario: 2003 Report," p. 15 (p. 24 of the PDF) for nitrogen; p. 20 (p. 29 of the PDF) for sulphur.
9. See "Air quality: perception vs. fact" beginning on page 11. Provincial AQI sites reported concentrations in the "poor" category only one percent of the time in 2003, and this was due to ozone and fine particulate matter believed to originate in the United States.
10. See "Types and sources of emissions originating in Ontario" beginning on page 19.
11. See "Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation," prepared by DSS Management Consultants Inc. and RWDI Air Inc. for the Ontario Ministry of Energy, and released in early May 2005.

Whether or not this estimate is valid, it ignores the myriad other sources of PM. In Ontario alone these other sources produced over 280 times as much PM as the provincial coal-fired generating plants.[14] In any case, it is estimated that most fine airborne particles in Ontario originate outside of the province. While the nature and makeup of these particles have not received as much scrutiny as ozone or other substances, we know enough about them to understand that ignoring them will render any analysis of health impacts egregiously incomplete. At the least, it will make it impossible to attribute health impacts to any specific source. This approach is analogous to searching for lost car keys only in areas illuminated by street lights, because that is where it is easiest to look.

Further, the government's study does not identify any actual victims. It is based on the hypothesized effects of two pollutants from two upwind Ontario coal plants—the closest of which is 125 kilometres southwest of the Greater Toronto Area, Canada's largest population centre. The body count is derived entirely from a statistical analysis, from which all anomalous results—i.e., those results that did not support the preferred conclusion—were removed.

Most important, the study plays down the effects of local sources of pollution, which are far more likely to have a much more direct effect on the local population. If coal generation really is responsible for 660 premature deaths each year, how many more premature deaths are attributable to other, larger sources of pollution, including on-road motor vehicles (the largest source category for smog precursors) and other large point source emitters? This number must be far greater. If the government were truly seeking to reduce premature deaths from air pollution, then its pollution reduction efforts should focus primarily on these other sources.

Unfortunately, it appears the coal-related body count is a public relations device to artificially inflate the urgency of closing the coal plants. We must not overlook the politics of the issue. The government needs a "scientific" basis for its claims that emissions from Ontario's coal plants have an impact on human health. It is obvious that this study is an attempt to provide this basis, regardless of rigour, validity, or relevance.

## Proper risk assessment, and appropriate action

From a high-level risk management perspective, it may appear prudent to assume that coal generation does play a significant role in air quality and public health—better to be safe than sorry. But a cascaded succession of exaggerated assumptions—all seemingly prudent, but all skewed toward a predetermined and highly improbable worst-case scenario—has produced a hopelessly distorted understanding of the problem. The recommended solution could prove to be far more costly and drastic than the problem really warrants.

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12. For example, the DSS/RWDI study assumes that an arbitrarily high proportion of nitrogen oxides from Lambton and Nanticoke react with "background" volatile organic compounds to form ground-level ozone. Presumably, if there were no nitrogen emissions then these reactions would not occur; hence there would be less ground-level ozone, and fewer people would die from breathing it. This line of reasoning neglects to consider that less nitrogen would mean higher VOC concentrations. It assumes that only ozone is dangerous, and that VOCs, though they are listed as a Criteria Air Contaminant, are harmless. Since high proportions of VOCs come from motor vehicles and are therefore more localized, any objective analysis of the health impacts of pollutants in ambient air ought to treat VOCs at least as seriously as ozone. The Energy Ministry's "Cost Benefit Analysis" stops well short of this—perhaps because coal generation produces so few VOCs (see Fig. 10 on page 23).
13. See "Cost Benefit Analysis," p. 67.
14. See "Particulates" on page 21.

The government is basing a major public investment decision on precisely this kind of exaggerated risk assessment. In this case, the government's planned solution to the problem of air quality—replacing inexpensive coal with expensive natural gas—will cost billions, perhaps tens of billions, of dollars more than the alternative.

Costs of this magnitude will have a profound effect on every fiscal projection and consideration. Clearly the government's plan to phase out coal deserves closer scrutiny than it has received so far. Even a cursory analysis of in-province contributions to emissions in Ontario's airshed reveals much greater amounts of more dangerous pollutants than nitrogen and sulphur (see "Carbon monoxide," "Particulates," and "Volatile organic compounds," below).

Add in the fact that roughly half of the pollutants in Ontario's airshed originate outside of Ontario, and the true impact of Ontario's four coal-fired plants on provincial air quality comes into clearer perspective.

This suggests that any rigorous effort to address air quality in Ontario will have little positive impact unless it focuses on reducing levels of carbon monoxide, particulates, and volatile organic compounds—as well as on nitrogen and sulphur from sources other than coal generation.

For example, since coal generation produces comparatively small carbon monoxide and particulate emissions, eliminating coal generation from Ontario's electricity system will do little to reduce concentrations of these pollutants. In the case of carbon monoxide, it could actually make the problem worse: replacing coal with natural gas will increase carbon monoxide levels, because natural gas combustion produces more CO than coal.

Eliminating coal entails actions and costs that are well out of proportion to the true problem posed by coal generation. It is also off the mark in terms of the main sources of air pollution in Ontario. The public understands that motor vehicles are the primary cause of air pollution. Closing the coal plants will add a huge cost to Ontario and its economy. When electricity prices rise after the coal plants are shut down, the government will be left to explain how it is that smog alerts continue to occur in spite of the hugely expensive switch to natural gas.

# Air quality: perception vs. fact

> During the 33 years following the first edition of this report in 1971, there has been consistent improvement in the majority of the air pollutants' concentrations measured in Ontario despite significant increases in population, economic activity and vehicle-kilometres travelled.—*Ontario Ministry of the Environment "Air Quality in Ontario: 2003 Report"*

FOR OVER THIRTY YEARS, ENVIRONMENT CANADA HAS BEEN regularly monitoring the pollutants in our air. The charts below (beginning on page 12) are for Toronto and show clearly that the air in that city has actually improved over the years. Charts of the same pollutants for Windsor, London, Hamilton, and Ottawa show the same trends.

These figures illustrate that Toronto's air, at least with respect to acid gas emissions, is cleaner now than it was before the major coal plants came into service. This is despite the significant growth in population in the Greater Toronto Area since the 1970s. The steady progress can be credited to continuous improvements in all emission controls in all areas, including electricity generation. Average concentrations of nitrogen dioxide decreased by 26 percent between 1975 and 2003. Concentrations of sulphur dioxide decreased by 86 percent between 1971 and 2003.[15]

However, the biggest change has been in the transportation sector, where catalytic converters have produced significant reductions in automobile emissions. Next-generation catalytic converters promise even greater reductions. See "CAC reduction technologies" on page 29.

Further, the Ontario Ministry of the Environment notes that there were no "very poor" air quality hours reported in Ontario in 2003. On average the Air Quality Index sites across the province reported "poor" air quality only one percent of the time. This was due to elevated levels of ozone and fine particulates ($PM_{2.5}$), from precursor emissions most likely originating in the United States.[16]

In spite of this, the general perception is that Ontario air quality is declining. This incorrect perception may be due to the fact that the number of so-called smog days has been increasing. The Ontario Ministry of the Environment was not in the practice of issuing smog alerts in the 1970s, yet the Ministry's data shows that pollution levels were higher then than they are now.

## The "anchoring trap"

The Ministry of the Environment began the practice of issuing smog alerts only relatively recently—in 1995. While such public alerts provide valuable information, their recent prominence may have also created the illusion that air quality is getting worse, similar to the way media coverage of sensational crimes has led to the illusion that the rate of crime is increasing in cities where statistics show it is decreasing.

15. See Ontario Ministry of the Environment "Air Quality in Ontario: 2003 Report," p. 15 (p. 24 of the PDF) for nitrogen; p. 20 (p. 29 of the PDF) for sulphur.
16. "Air Quality in Ontario: 2003 Report," pp. 26–27 (pp. 35–36 of the PDF).

This is an example of the "anchoring trap"—a psychological quirk that makes us prone to giving disproportionate weight to the first information we receive. In the case of smog alerts, since we were not accustomed to receiving them prior to 1995, when the Ministry of the Environment began issuing them in that year we naturally assumed that this was because air quality was getting worse.

Coupled with incorrect and exaggerated claims by anti-coal lobbyists that coal generation plays a major role in producing poor air quality, the recent prominence of smog alerts has created an impression that is exactly the opposite what is really happening.

Contrary to these incorrect claims, emissions of smog-causing pollutants from coal generation have dramatically decreased over the past two decades, even though coal produces more electricity now than it did two decades ago. (For an illustration of the impressive results of pollution-reduction efforts at Ontario's largest coal plant, see Fig. 14 on page 30.) Further significant reductions are possible, provided the provincial government finishes installing cleaner coal technology on every unit at all of Ontario's coal plants.

While the figures below illustrate that air pollution levels have fallen over the past three decades, this is not an argument to cease efforts to further reduce emissions from coal generation. These efforts have been very successful so far, and they should continue. It is simply to illustrate that air quality has not been declining, and that coal generation does not play the decisive role in Ontario's air quality.

Fig. 1 **Ozone levels in Toronto, 1974–1997, mean concentrations (parts per billion)**

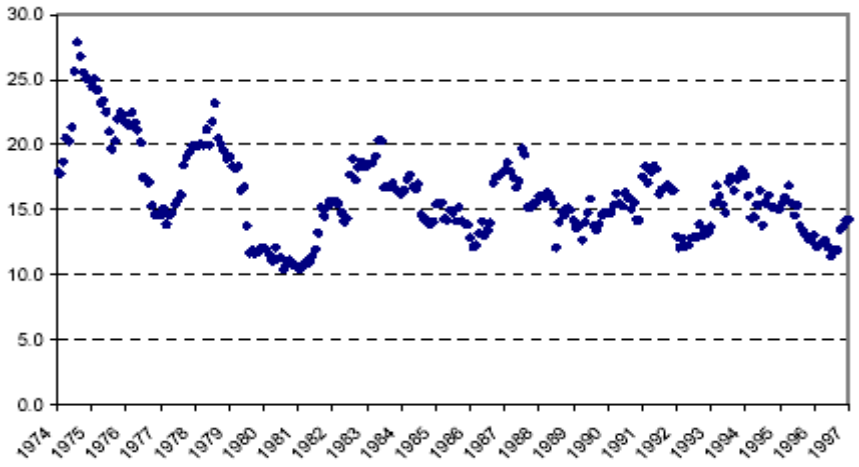



Fig. 2 **$SO_2$ levels in Toronto, 1974–1999, parts per billion. The thick line represents Environment Canada's standard for ambient air.**

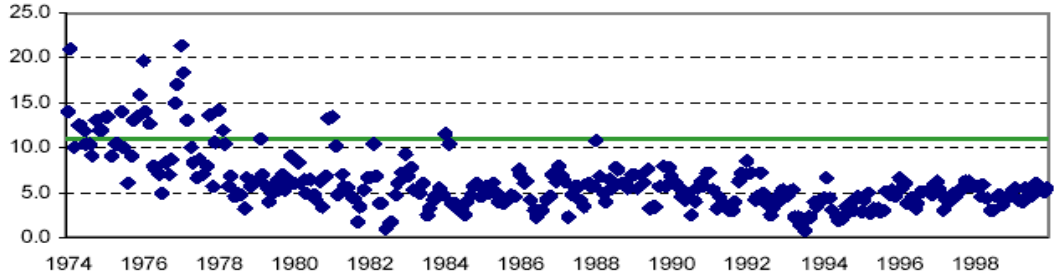
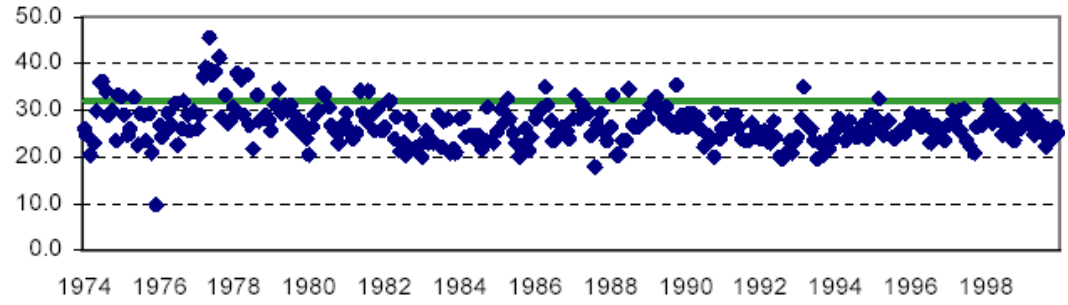


Fig. 3 $NO_2$ **levels in Toronto, 1974–1999, parts per billion. The thick line represents Environment Canada's standard for ambient air.**




## The real impact of coal generation

In 2004, RWDI Consulting Engineers, a consultancy, ran a number of computerized simulations comparing southern Ontario air quality in two scenarios: one in which Ontario's coal plants have been retrofitted with cleaner coal technology; the other in which new natural gas plants have replaced the coal plants. Specifically, the simulations looked at the degree to which each of these technological alternatives would have contributed to improvements air quality during a well-known smog episode in 1999.

The RWDI model, peer-reviewed by Dr. Diane Michelangeli of York University, concluded that both alternatives—retrofitting the existing coal plants with cleaner coal technology or replacing their capacity with new natural gas–fired plants—led to only slight reductions in ground level concentrations of ozone and fine particulates during a summer smog episode.

This suggests that power generation played a very small, if not negligible, role in pollution formation in Ontario during that smog event. This contradicts claims that Ontario's poor air quality is the result of coal generation.

This result casts new light on the decision to shut Ontario's coal plants. If their true contribution to Ontario's air pollution inventory is so slight, then the payoff, in improved air quality, that will result from closing them and replacing them with new natural gas–fired plants, will also be slight.

Indeed, based on figures provided by Babcock and Wilcox, a manufacturer of emission control devices, the cleaner coal option reduces combustion emissions by nearly the same proportion as combined cycle natural gas generation.

The RWDI model supports this. It shows the effects of cleaner coal and natural gas to be very similar in terms of levels of $NO_x$ and $SO_2$, the main pollutants with which coal combustion is associated.

But the cost of this switch in generating fuels will be huge—$5.3 billion in capital alone, and, because of volatile natural gas prices, unknown operating costs.

If natural gas prices remain at their current high levels, then the net effect of the Ontario government's decision to close the coal plants will be higher electricity prices and air quality that is much the same as it is now.

The Ontario Medical Association has recommended that further action be taken to improve air quality, by means of setting stronger environmental performance standards for emissions from not only generating plants, but also from vehicles, small engines, fuel refining,

and other sources. In the case of coal plants, this means equipping them with emission control devices, not closing them down.

# International sources of air pollution in Ontario

THE UNFORTUNATE REALITY FOR RESIDENTS of southern and central Ontario is that about half of our air pollution is imported. For example, the Ontario government estimates that U.S. sources contribute 80 percent of the airborne sulphate concentrations in Windsor and 60 percent in Toronto. A 2001 study found that mortality and morbidity rates from all causes were higher in Windsor than in the rest of Ontario.[17]

This study found that vehicular traffic in the Detroit–Windsor corridor—the most heavily travelled point on the Canada–U.S. border—is the biggest local source of air pollution in the area. But pollution originating in Detroit and upwind Michigan is also a major source. When the wind is south to southwesterly (which is generally the case during warm weather in the summer; see Fig. 6), it is unlikely that Ontario coal plants play much of a role in Windsor.

In the case of nitrogen oxides and volatile organic compounds, the two main precursors to smog formation, U.S. sources contribute 90 percent of the concentrations in Windsor, 70 percent in London, and half in Toronto.[18]

The Ontario government also notes in its 2003 report on provincial air quality that U.S. sources are likely the primary cause of elevated levels of ozone and fine particulate matter in Ontario. Elevated levels of these two pollutants accounted for 99 percent of Ontario's "poor" air quality ratings during 2003.[19] The Ontario government also estimates that U.S. sources account for 50–60 percent of Ontario's airborne sulphur dioxide (see Fig. 4).

This situation is not surprising. There are 55 million registered motor vehicles in the states of Michigan, Ohio, and Illinois, all of which are upwind of Ontario.

In fact, the industrial Midwest and the Ohio valley generate much of the pollution load measured in Ontario, from Windsor to Ottawa, during poor air quality episodes. This is because of the meteorological conditions that prevail in this part of North America. Summertime air movement is often characterized by clockwise flow around a high-pressure centre. When a high pressure centre sits over the northeast part of the Great Lakes, this clockwise air flow tends to draw warm, moist air up from the Gulf of Mexico—which passes directly over the U.S. industrial heartland before entering southern Ontario. Fig. 5 on page 16 illustrates the weather pattern that precipitates these conditions, and Fig. 6 on page 17 illustrates the resulting south–southwesterly air flow during this stage in the cycle. High pressure centres tend to produce clear skies, light winds, warm temperatures, and high relative humidity. These are the key meteorological ingredients of poor air quality episodes.

17. M. Gilbertson et al, "Community health profile of Windsor, Ontario, Canada: Anatomy of a Great Lakes area of concern," in *Environmental Health Perspectives*, 109, December 2001, pp. 827–843.
18. See Ontario Ministry of the Environment, http://www.ene.gov.on.ca/envision/techdocs/4016e.htm#int.
19. Keep in mind, however, that provincial Air Quality Index monitoring sites indicated "poor" air quality only one percent of the time in 2003. Ozone ($O_3$) accounted for nearly two-thirds of the "poor" air quality hours recorded in that year. Fine particulate matter ($PM_{2.5}$) accounted for over a third. See "Air Quality in Ontario: 2003 Report," Ontario Ministry of the Environment, 2003, pp. 26–27 (pp. 35–36 of the PDF). For information on how to interpret the Air Quality Index, see http://www.ene.gov.on.ca/envision/techdocs/3958e01.htm.

Fig. 4 **Sources of $SO_2$ in Ontario's airshed**

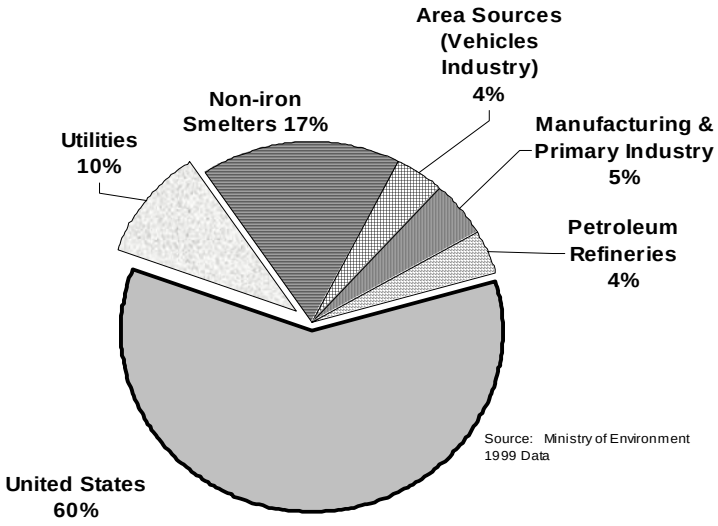



Fig. 5 **Generalized synoptic weather pattern over southern Ontario conducive to elevated pollutant levels. Note the south–southwesterly air flow.**
Source: Environment Canada

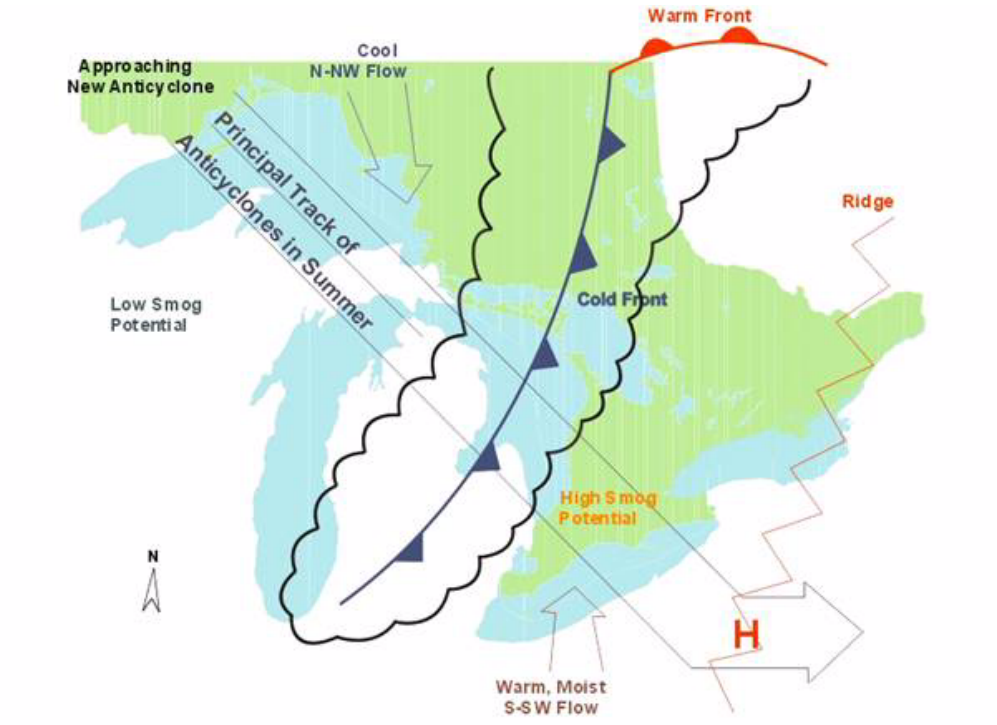
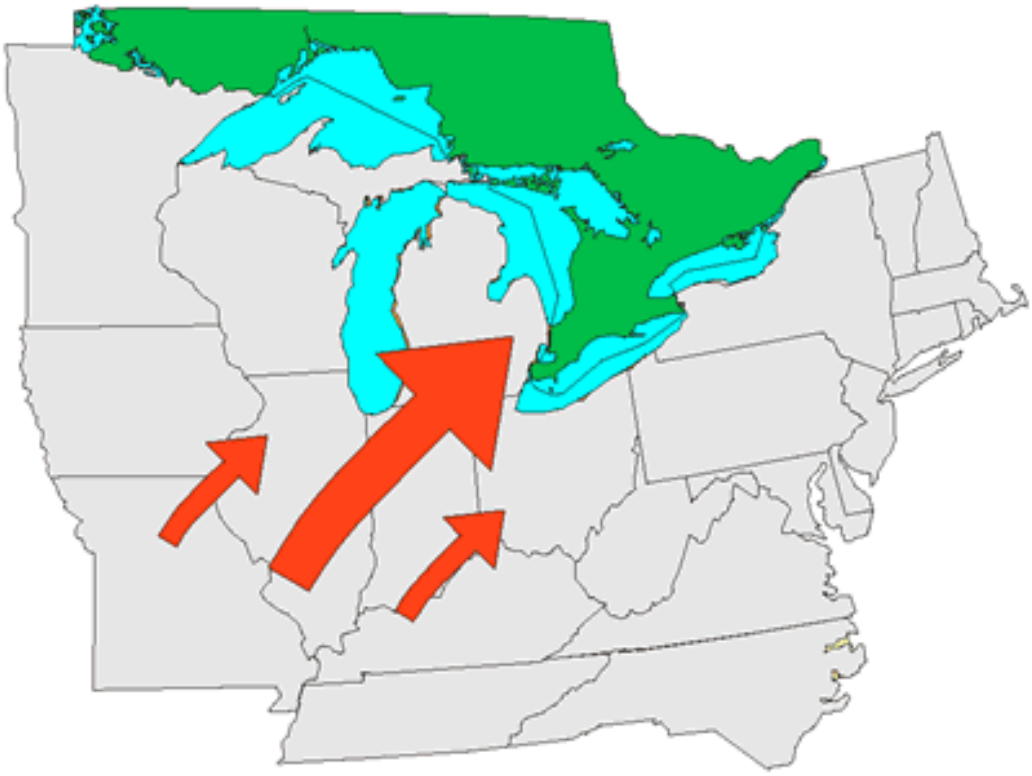


Fig. 6 **South to southwesterly summertime air flow into Ontario**
Source: Ontario Ministry of the Environment



# Types and sources of emissions originating in Ontario

EMISSIONS FROM ONTARIO'S COAL-FIRED GENERATING PLANTS have been, and still are, the subject of much controversy and confusion. Much of the confusion stems from the complexities surrounding the varying properties of the emission products of fossil fuel combustion. Still more confusion surrounds the effects of fossil fuel emissions on humans and the environment.

The anti-coal lobby has taken advantage of this confusion. In its efforts to promote expensive natural gas as a viable alternative to far-less-expensive coal, the anti-coal lobby tries to show that it is impossible to make coal emissions any cleaner. Their main tactic is to exploit confusion surrounding classifications of emissions.

This section attempts to clarify and shed some light on the issue of man-made air emissions in general and the role of coal generation in particular.

## The difference between air pollution and greenhouse gas

Man-made emissions include a wide variety of substances with varying properties. Essentially, these fall into two groups: Criteria Air Contaminants, or CACs; and Greenhouse Gases, or GHGs. CACs are often simply called "air pollution."

It is important to remember that CACs are dangerous to humans, which is why governments regulate their levels in ambient air. On the other hand, the main GHG, carbon dioxide ($CO_2$), is thought to be responsible for global warming. This is why scientists are concerned about it. It is not an air pollutant, because at most concentrations it is harmless when inhaled. (In fact $CO_2$ is an essential ingredient for plant growth.) So, to repeat: $CO_2$ is not an air pollutant. The concern surrounding it has to do with its global warming properties.

CACs are regulated by the federal and provincial governments, and GHGs are covered by the Kyoto Treaty.

CACs and GHGs are not mutually exclusive. It is possible for a substance to be both a CAC and a GHG. An example is ammonia ($NH_3$).[20]

**Carbon dioxide and "air pollution"** In spite of the basic difference between CACs and $CO_2$ (the main GHG), it is a common practice among opponents of coal generation to lump the two together and refer to both as "air pollution."

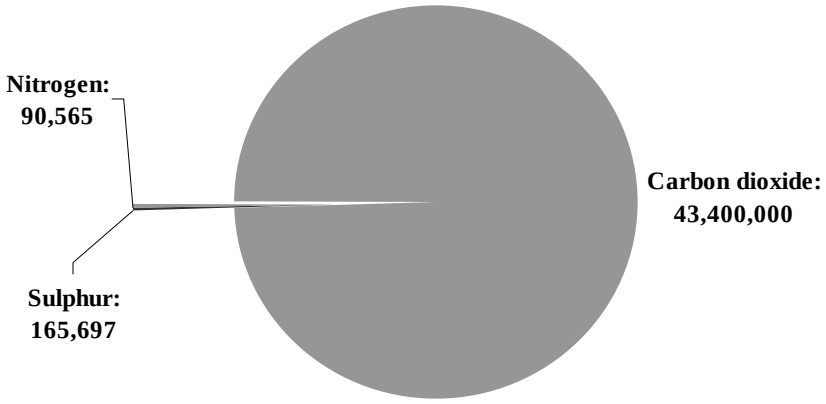
This is a public relations ploy, and it serves a narrow corporate purpose. Coal combustion produces far more $CO_2$ than all CACs combined. For this reason, CACs (specifically, nitrogen and sulphur) comprise only a tiny percentage of *total emissions*—see Fig. 7 on page 20. But it is nitrogen and sulphur, not $CO_2$, that pose the risk to human health. Therefore these two pollutants are—quite properly—the target of emission reduction efforts at coal plants. But because of their small proportions relative to total emissions, any reduction in nitrogen and sulphur, no matter how large it is, will appear small if it is compared with total emissions.

20. Ammonia is technically a precursor to particulate formation, which is why it is classified as a CAC. As a greenhouse gas, its global warming potential is roughly 1.5 times that of carbon dioxide. See "Canada's Greenhouse Gas Inventory, 2001," Environment Canada, 2004, p. 57 (p. 74 of the PDF).

But this is precisely the tactic anti-coal lobbyists use, in order to promote expensive natural gas as an alternative to coal generation. To justify removing coal from the provincial generation mix, it helps to make it look like it is impossible to make coal any cleaner. Anti-coal lobbyists accomplish this purpose by making it look like emission-reduction devices are ineffective.

So, when Ontario Power Generation publishes a report on the performance of emission-reduction efforts at its coal-fired plants, the anti-coal lobby's tactic is to misrepresent the information given in the report. By comparing the reported reductions in nitrogen and sulphur—which are the target of emission-reduction efforts—with total emissions, anti-coal lobbyists can then point to the small percentage in order to "show" that the reductions are insignificant.

Fig. 7 **Carbon dioxide ($CO_2$), nitrogen, and sulphur emissions from electricity generation in Ontario in 2000, in tonnes. $CO_2$, which is harmless when inhaled by humans, made up the overwhelming bulk (99.4 percent) of total emissions. Combined, nitrogen and sulphur—the target of emission-reduction efforts—accounted for less than three-fifths of one percent of total emissions.[a]**




a. In 2000, nitrogen and sulphur emissions from electricity generation in Ontario were 90,565 tonnes and 165,697 tonnes respectively. Carbon dioxide emissions were 43.4 million tonnes. Total emissions were therefore nearly 43.7 million tonnes, of which $CO_2$ accounted for over 99.4 percent. Even if nitrogen- and sulphur-removal technology were completely effective and capable of eliminating all nitrogen and sulphur emissions, the reduction from total emissions would still only be less than three-fifths of one percent. (Sources: for nitrogen and sulphur, see Environment Canada, CAC emission summaries at http://www.ec.gc.ca/pdb/cac/cac_ESummaries_e.cfm; for GHGs, see Environment Canada, "Canada's greenhouse gas inventory, 1990–2001" p. 186.)

But nitrogen and sulphur comprised a tiny percentage of total emissions to begin with, so any reduction in these pollutants will still appear tiny when compared with total emissions. So, as you can see in Fig. 7, comparing nitrogen and sulphur reductions with total emissions is false and misleading. Carbon dioxide is not a pollutant. It is harmless to humans; in fact it is as essential to a healthy tree as oxygen is to a healthy human. In spite of this, opponents of coal generation continue to call these total emissions "dirty." This misrepresentation allows the anti-coal lobby to mislead the public into believing that emission-reduction technology does not work, and that the only way to deal with coal emissions is to stop using coal and switch to natural gas.

This is not to say that $CO_2$ is nothing to be concerned about. Climate change is a serious global problem, and it is imperative that Canada—and every province and territory in Canada—do its part in stemming GHG emissions. In Ontario, there is an extremely effective—and historically proven—way to dramatically reduce $CO_2$ emissions in the electricity sector. This is to increase the amount of carbon-free nuclear generation in the system. In 1994–1995,

Ontario's electricity generating sector produced less than half the GHGs as in 2001, and that was due to the larger nuclear contribution in that period.[21]

The anti-coal lobby has not been forthcoming on the matter of greenhouse gas either. They rarely mention that unburnt natural gas is itself a potent GHG, 21 times as powerful as $CO_2$—or that burning it converts its main constituent, methane, into $CO_2$ (see "Methane," on page 26).

## Criteria Air Contaminants

Criteria Air Contaminants are pollutants that are known to harm humans and the environment. In Canada they are defined by legislation and regulation. Descriptions of the major ones are given below.

**Carbon monoxide** Carbon monoxide (CO) is the most dangerous and the second-most prevalent of Ontario's man-made Criteria Air Contaminants. A colourless, odourless, and tasteless gas, CO is the world's leading cause of injury and death by poisoning.[22] In half the cases of serious CO poisoning, victims suffer brain damage.[23]

Carbon monoxide is a product of incomplete combustion. Environment Canada estimates that man-made sources in Ontario put over 2.6 million tonnes of CO into the air in 2000.

The overwhelming majority of Ontario's man-made CO emissions were from transportation sources: cars, trucks, and other motor vehicles (see Fig. 8). These sources produced over 2.3 million tonnes of CO in 2000—over 380 times as much as all the coal plants combined.[24]

Electric power utilities in this province, including coal-fired generating plants, contributed less than three-tenths of one percent to Ontario's total CO emissions.

**Particulates** Particulates are fine dust particles that consist of solids or liquids from smoke, dust, or other substances that can hang in the air and remain as separate particles for long periods of time.

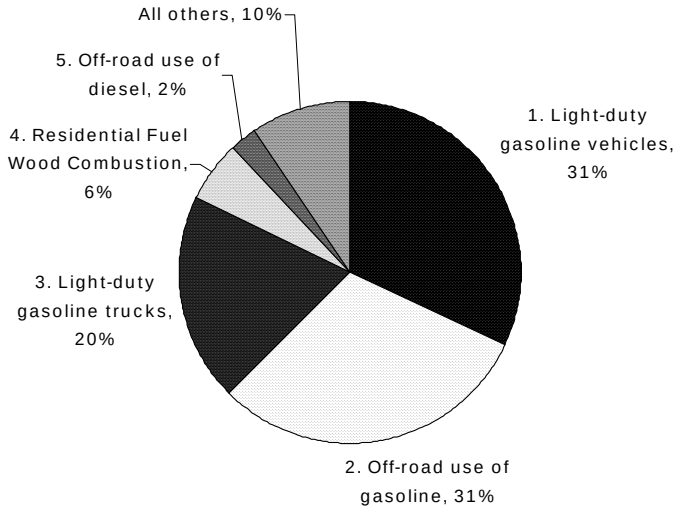
The smallest particulates can be inhaled and cause serious breathing problems, especially for children, people with asthma, and the elderly.

Particulates are classified according to their size. All those with a diameter of less than 100 microns (a micron is $^1/_{100}$ of a centimetre) are classified as Total Particulate Matter (TPM). Particulates with a diameter of less than or equal to 10 microns are classified as $PM_{10}$, and those with a diameter of less than or equal to 2.5 microns are classified as fine particulate matter ($PM_{2.5}$).

Many processes produce particulates. These include burning gas, wood, and other fuels. However, as you can see in Fig. 9, the biggest source of TPM in Ontario, by far, is dust from

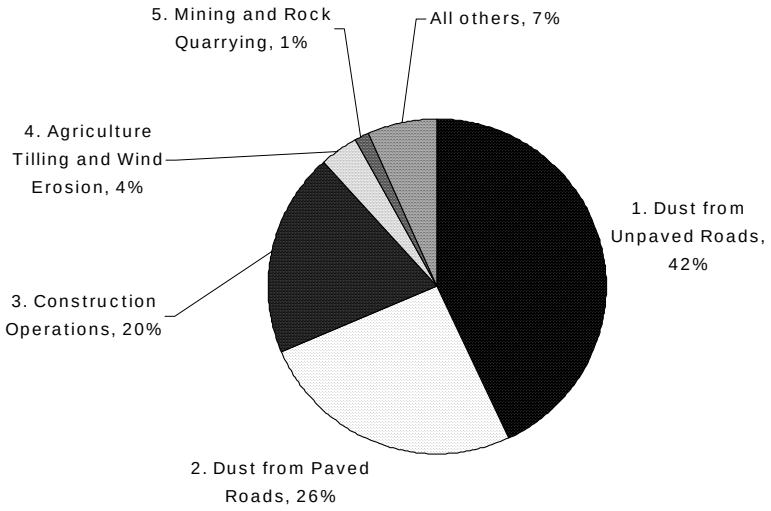
21. See Environment Canada, "Canada's Greenhouse Gas Inventory, 1990–2001," p. 186. The section "Greenhouse gas reduction technologies," beginning on page 32, describes how Ontario's electricity was nearly 90 percent carbon-free in 1994–1995.
22. According to American toxicologist E.P. Krenzelok, "carbon monoxide is responsible for more poisoning fatalities every year than any other toxic agent"; see E.P. Krenzelok, quoted in *Carbon Monoxide Toxicity*, David Penney, ed., p. 1.
23. See "Toxicology: Long Term Effects of CO Poisoning are an Autoimmune Reaction," in *Obesity, Fitness & Wellness Week*, October 2, 2004. Article refers to a study by Stephen R. Thom of the University of Pennsylvania School of Medicine, released online in September 2004.
24. Environment Canada's Criteria Air Contaminants Emission Summaries for 2000; see http://www.ec.gc.ca/pdb/cac/ape_tables/co2000_e.cfm.

Fig. 8 **Carbon monoxide in Ontario, top five sources in 2000. Total was 2.68 million tonnes. Combined, the top five sources produced 400 times as much CO as all power generating plants.**
Source: Environment Canada, 2000 CAC emission summaries


All others, 10%
5. Off-road use of diesel, 2%
4. Residential Fuel Wood Combustion, 6%
3. Light-duty gasoline trucks, 20%
1. Light-duty gasoline vehicles, 31%
2. Off-road use of gasoline, 31%

unpaved roads, which is the result of the continued "grinding up" action of vehicles on sand and gravel. Particulates from this source include sand, gravel, asphalt, rubber from tires, etc. Coal generation contributes relatively minor proportions: less than four-tenths of one percent in 2000.

Fig. 9 **Total particulate matter (TPM) in Ontario, top five sources in 2000. Total was 3.6 million tonnes.**
Source: Environment Canada, 2000 CAC emission summaries


5. Mining and Rock Quarrying, 1%
All others, 7%
4. Agriculture Tilling and Wind Erosion, 4%
1. Dust from Unpaved Roads, 42%
3. Construction Operations, 20%
2. Dust from Paved Roads, 26%

**Volatile organic compounds** Volatile organic compounds include gasoline, industrial chemicals such as benzene, solvents such as toluene and xylene, and dry cleaning solvents.

Organic chemicals all contain the element carbon (C), and are the basic chemicals found in living things. They are therefore found in products derived from living things, such as coal,

petroleum, and refined petroleum products. Along with carbon, VOCs contain elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulphur, or nitrogen.

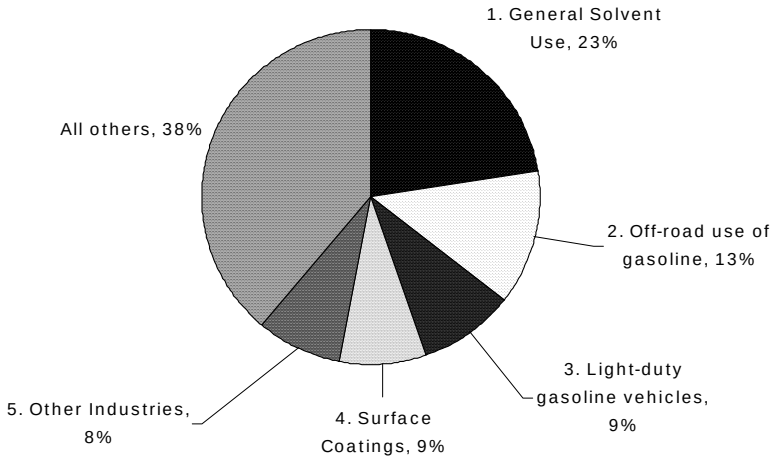
They are called "volatile" because they vaporize, or evaporate, readily. At room temperature and normal atmospheric pressure, vapours escape easily from volatile liquid chemicals. Emissions are dependent on temperature, vapour pressure of gasoline, and humidity.

Many volatile organic compounds are also hazardous air pollutants. At high levels of exposure, many VOCs can cause central nervous system depression (drowsiness, stupor). All can be irritating upon contact with the skin, or to the mucous membranes if inhaled. Many are known to cause cancer in animals, and some are suspected of causing—or in the case of benzene, are known to cause—cancer in humans. When combined with nitrogen oxides, VOCs react to form ground-level ozone, which is a major component of smog.

Many of the organic chemicals we use do not occur in nature, but were synthesized by chemists in laboratories. Major sources of VOCs are man-made substances like solvents, paints, glues, and coatings. VOCs are also released when fuels such as gasoline, wood, coal, or natural gas are not burned completely.

In Ontario, the greatest source of VOCs is solvent use (see Fig. 10 on page 23). This accounted for nearly a quarter of provincial sources in 2000. Coal-fired electricity generation is not a significant source; it contributed $^{1}/_{100}$ of one percent to the provincial total in 2000.

Fig. 10 **Volatile organic compounds in Ontario, top five sources in 2000. Total was 650,000 tonnes. Top five sources contributed over 4,000 times as much VOCs as coal generation.**
Source: Environment Canada, 2000 CAC emission summaries


1. General Solvent Use, 23%
2. Off-road use of gasoline, 13%
3. Light-duty gasoline vehicles, 9%
4. Surface Coatings, 9%
5. Other Industries, 8%
All others, 38%

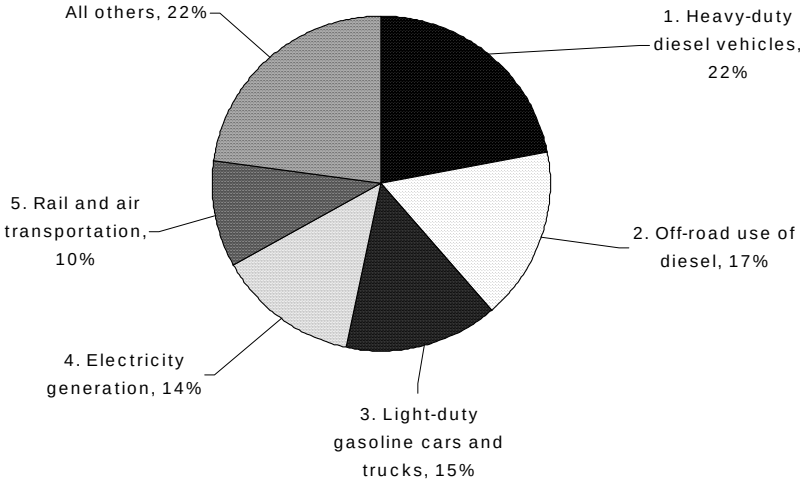
**Nitrogen oxides** Nitrogen oxides ($NO_x$) are a family of gases that are composed of nitrogen and oxygen. Two of the most toxicologically significant nitrogen oxides are nitric oxide and nitrogen dioxide. Both are nonflammable and colourless to brown at room temperature.

Nitrogen oxides are a product of fossil fuel combustion, as well as of activities such as arc welding, electroplating, engraving, and dynamite blasting. Nitrogen oxides are broken down rapidly in the atmosphere by reacting with other substances commonly found in the air.

For example, when nitrogen dioxide reacts with chemicals produced by sunlight, it leads to the formation of nitric acid, which is a major constituent of acid rain. Nitrogen dioxide also itself reacts with sunlight, and with other chemicals, which leads to ozone and smog formation.

According to Environment Canada, Ontario $NO_x$ emissions in 2000 amounted to over 666,000 tonnes. The biggest source of $NO_x$ in Ontario is motor vehicles. As you can see in Fig. 11, motor vehicles were responsible for 63 percent of the province's $NO_x$ emissions in 2000. Road transportation—which includes heavy-duty diesel vehicles as well as light-duty gasoline cars and trucks—accounted for well over half that proportion. Electricity generation accounted for 14 percent.

Fig. 11 **Nitrogen oxides in Ontario, top five sources in 2000. Total was 666,447 tonnes.**
Source: Environment Canada, 2000 CAC emission summaries


All others, 22%
1. Heavy-duty diesel vehicles, 22%
2. Off-road use of diesel, 17%
3. Light-duty gasoline cars and trucks, 15%
4. Electricity generation, 14%
5. Rail and air transportation, 10%

The general population is primarily exposed to nitrogen oxides by breathing in air. People who live near combustion sources such as motor vehicles, wood or kerosene stoves may be exposed to higher levels of nitrogen oxides.

**Sulphur Oxides** Sulphur oxides ($SO_x$) are compounds containing sulphur and oxygen, such as sulphur dioxide ($SO_2$) and sulphur trioxide ($SO_3$). The major source of sulphur oxides is the combustion of sulphur-containing fuels, primarily coal and fuel oil. Sulphur dioxide is a toxic substance that can impair breathing, and is a primary component of smog and acid rain. It is also a co-factor in the formation of fine particulates.

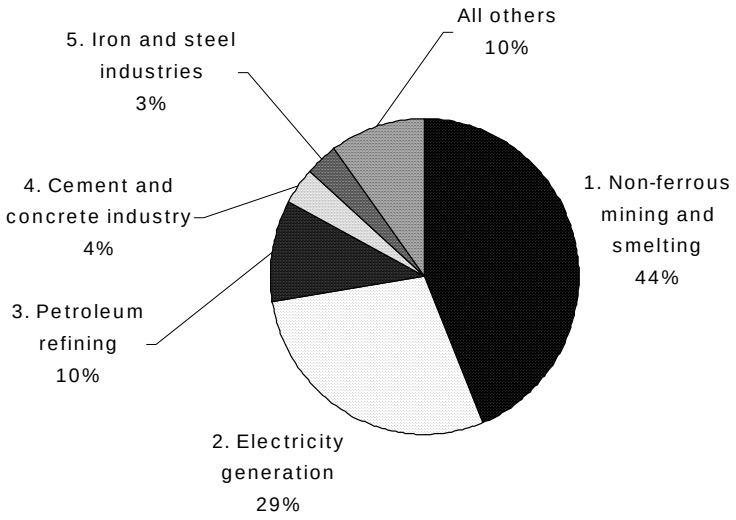
As you can see in Fig. 12, the largest source of $SO_x$ in Ontario is non-ferrous mining and smelting. Electricity generation currently accounts for 29 percent of in-province sources of $SO_x$.

**Mercury** The Government of Ontario regulates a number of substances that can be hazardous to health but occur in very low concentrations. These are regulated by "point of impingement" (POI) limits, designed to ensure that no individual is unduly exposed.

Mercury falls into this category. Mercury is a heavy metal that occurs naturally in the environment. It is present in all coal, typically in concentrations of 0.08 to 0.2 parts per million by weight.

Mercury occurs in combustion flue gas in its elemental, or metallic, form, and it is also present in some organic and inorganic compounds. These emissions tend to be extremely low. A test in 2000 revealed that mercury emissions from the Nanticoke station, one of the largest of its kind in the world, were one ten-thousandth of the Ontario government's POI limit.

Fig. 12 **Sulphur oxides in Ontario, top five sources in 2000. Total was 580,495 tonnes.**
Source: Environment Canada, 2000 CAC emission summaries




It is possible to remove mercury from flue-gas emissions by using wet and dry flue gas desulphurization (FGD) devices and particulate control devices such as airbags and electrostatic precipitators. These devices have long been in use at Ontario coal plants, especially since 1994, when FGD devices, also called scrubbers, were installed on two units at the Lambton generating plant.

Canadian man-made mercury emissions have been generally decreasing, from 33 tonnes in 1990 to 6 tonnes in 2000.[25] While scrubbers and particulate controls at coal generating plants have played a part in this, the majority of mercury reductions have occurred because of actions taken by other industries, which are bigger emitters.

A number of experimental methods of removing elemental, or metallic, mercury from coal combustion emissions are in development and are close to commercial rollout. One of these processes, currently being demonstrated on a federal government–funded project in Saskatchewan, introduces activated carbon into flue gases downstream from other emission control devices.[26]

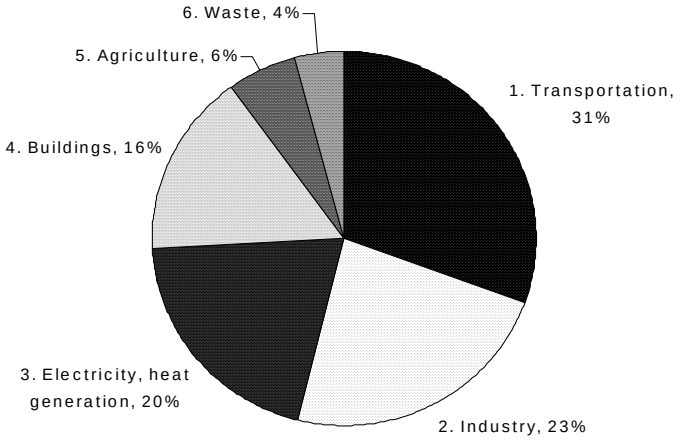
## Greenhouse Gases

Greenhouse gases (GHGs) contribute to global warming and climate change. They trap heat in the atmosphere and prevent it from escaping into outer space.

Coal combustion at Ontario generating plants contributed just under 20 percent of the province's total GHGs in 2001 (see Fig. 13). This represented 5 percent Canada's total GHG inventory in 2001. Electric power utilities across Canada produced 19 percent of the national total.

25. See United Nations Environmental Programme report "Global Mercury Assessment," 2002. Document can be accessed at http://www.chem.unep.ch/mercury/Report/Summary%20of%20the%20report.htm#Chapter2.
26. In early August 2005, Colorado-based ADA-ES Inc. announced it had received a contract to provide activated-carbon injection equipment to a new coal-fired power plant in the U.S. midwest. ADA-ES claims to have demonstrated this technology at 20 coal-fired plants across the U.S., and that the current contract represents the first commercial rollout.

Fig. 13 **Sources of greenhouse gas in Ontario, 2001. Total is 201 million tonnes.**
Source: Environment Canada, "Canada's Greenhouse Gas Inventory, 1990–2001"




**Carbon Dioxide** Carbon Dioxide ($CO_2$) is the most prevalent man-made GHG and for this reason is the benchmark against which the potency of other GHGs is measured. The largest source of $CO_2$ is fossil fuel combustion. Fossil fuel combustion was responsible for nearly three-quarters of Canada's total GHGs in 2001.

Carbon dioxide is not yet a regulated emission, but it is subject to the requirements of the Kyoto Protocol, to which Canada is a signatory.

There is considerable debate over whether $CO_2$ should be classified as a pollutant. As mentioned on page 19, it is an essential ingredient in the process of photosynthesis, by which most plants grow. At normal concentrations it is harmless when ingested by humans. But because it has high global warming potential, and is a by-product of combustion along with other true pollutants, some believe it belongs in the pollution category.

This debate over whether $CO_2$ deserves classification as a pollutant is likely to continue. The State of California's proposed new automobile emissions regulations—which would force automakers to develop vehicles that consume 30 percent less fuel by 2016—could force the issue in the U.S.

This would have important implications in Canada. There was already an attempt to write this into legislation, during the most recent Canadian Parliamentary session. While that attempt did not succeed, there is always a possibility that its proponents could try again. Should $CO_2$ emissions become subject to regulation, the costs of abating carbon emissions will become a permanent feature of companies' financial realities. This could change the competitive landscape in many industries and sectors.

**Methane** Carbon dioxide is not the only greenhouse gas we need to be concerned about. In fact, methane ($CH_4$), which is the main constituent of natural gas, is a far more potent greenhouse gas. Its global warming potential is 21–23 times that of $CO_2$.

It is important to remember this propensity of methane, because it gives a fuller picture of the GHG impacts related to natural gas. While natural gas *combustion* at end use produces roughly a third of the $CO_2$ that coal combustion produces for an equivalent amount of heat, the *process* and *fugitive* GHG emissions related to the natural gas and liquified natural gas (LNG) industries are substantial. In 2001 Canada's fugitive methane emissions were the equivalent of 24 million tonnes of $CO_2$.[27]

Atmospheric concentrations of methane from human activity have risen by about 145 percent since the 1700s. Recent measurements at Alert, NWT show that the concentration of methane has risen from roughly 1,725 parts per billion (ppb) in 1985 to roughly 1,830 ppb in 2000.[28]

Natural gas wells, processing plants, pipelines, and generating plants—as well as LNG facilities and pipeline transportation—are significant sources of fugitive methane and combustion and process $CO_2$.

These additional emissions—and the significant costs of natural gas—must be equally considered as Ontario evaluates alternative power generating fuels.

27. See Environment Canada, "Canada's greenhouse gas inventory, 1990–2001," p. 4 (p. 21 of the PDF).
28. Environment Canada, "Canada's greenhouse gas inventory, 1990–2001," pp. 12–13 (pp. 29–30 of the PDF).

# Reducing CACs and GHGs

EMISSION CONTROL EFFORTS AND TECHNOLOGY at Ontario coal plants have resulted in dramatic emission reductions. Though only six of the province's fourteen coal-fired generating units are equipped with emission-control devices, nitrogen and sulphur emissions are far less than they were previously—even though coal-fired units now generate more electricity.

Given that this partial implementation has been so successful, it is not difficult to see that a full implementation—installing emission controls on all units—would reduce emissions even further.

## CAC reductions at Ontario's coal plants

When Ontario's coal plants were first built, the overriding environmental concern was on reducing particulate, or smoke, emissions. To capture particulates, Ontario Hydro installed electrostatic precipitators.[29] As a result, coal-fired power plants now contribute small proportions of particulates.[30]

Over time the focus of concern shifted to emissions of sulphur dioxide and nitrogen oxides. Ontario Hydro, and its successor company Ontario Power Generation, adopted a series of measures that cut sulphur and nitrogen emissions.

Recently, because of the Kyoto Protocol on climate change, public concern has also turned to carbon dioxide and methane.

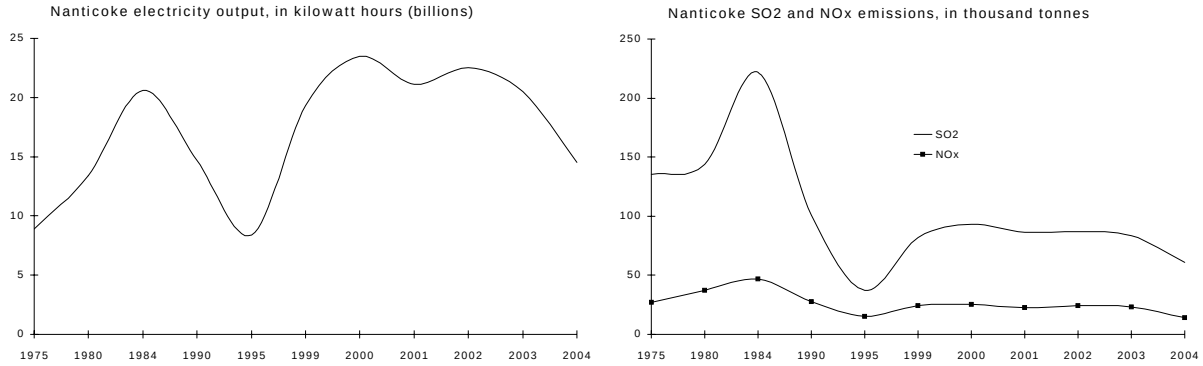
Nitrogen and sulphur removal devices are currently in use at two of Ontario's coal-fired plants, Nanticoke and Lambton. Ontario Power Generation employs a variety of devices and processes to reduce emissions of nitrogen and sulphur at these plants. These include the following.

- Using a larger proportion of low-sulphur Powder River Basin coal.
- Blending coals from different sources to obtain lower $NO_x$ emissions.
- Installing low-$NO_x$ burners on all units at the Nanticoke and Lambton stations.
- Installing Overfire air ports on one unit at Nanticoke.
- Installing Selective Catalytic Reduction (SCR) devices, for $NO_x$ reduction, on four units (Nanticoke 7 and 8, Lambton 3 and 4).
- Installing Flue Gas Desulphurization (FGD) devices, also known as scrubbers, on Lambton units 3 and 4.

29. Electrostatic precipitators use high voltage electrodes to impart a negative charge to the particulates in flue gases. The negative charge attracts the particulates to a grounded collecting surface, thereby removing them from smokestack emissions. This process can remove up to 99 percent of particulates.
30. Electric power generation contributed less than four tenths of one percent of total particulate matter in Ontario in 2000. See "Particulates," on page 21.

Fig. 14 shows the results of these measures in the case of the Nanticoke generating station.

Fig. 14 **Nanticoke Generating Station electricity output and emissions, 1975–2004. Emissions were reduced even though only two of the station's eight units are equipped with nitrogen-removal devices, and none is equipped with a sulphur-removal device.**
Source: Ontario Power Generation




As you can see, though electricity output was 14 percent higher in 2000 than in 1984, emissions of sulphur were only 42 percent of the 1984 level. Nitrogen oxide emissions in 2000 were just over half the 1984 amount.

The government of Ontario is urging other large emitters of sulphur and nitrogen to reduce their own emissions of these pollutants. It posted guidelines in spring 2004 that framed a process for selecting various reduction technologies.[31] These included emission intensity rates for industries that emit far greater quantities of sulphur than Ontario's coal plants.[32]

## CAC reduction technologies

Most emissions of carbon monoxide, volatile organic compounds, and nitrogen oxides come from motor vehicles. The primary device for reducing these CACs is a catalytic converter on an automobile.

A catalytic converter is a simple device that is connected to a car's exhaust pipe between the engine and the muffler. It contains an internal honeycomb structure, which is coated with platinum group–metal catalysts. When exhaust gases pass through the catalytic converter, the platinum catalysts convert carbon monoxide, VOCs, and nitrogen oxides into harmless substances like carbon dioxide, water, nitrogen, and oxygen.

While platinum-based catalytic converters have succeeded in reducing transportation-related pollution emissions, emissions from this sector are still significant. This is because platinum catalysts do not convert pollutants when the device is cold. Thus there are periods,

31. See Ontario Ministry of the Environment, "Ontario's Industry Emissions Reduction Plan," at http://www.ene.gov.on.ca/envision/techdocs/#airquality. This document proposes an emission cap system, with levels assigned to various industries. The guideline is careful to note that emission-reduction technology must be both effective and "economically achievable"—i.e., affordable (see "Appendix III: Guidelines for Identification of Best Available Control Technology"). The same criteria ought to apply to electricity generation.
32. An example of a major sulphur-emitting industry is non-ferrous mining and smelting, which contributed 44 percent of Ontario's emissions in 2000 (see Fig. 12 on page 25).

of up to five minutes after startup in the summer and much longer in the winter, when a car or truck is emitting raw pollutants. Next-generation catalytic converters are being developed which will use different catalytic materials that work even when the device is cold.

In the case of coal generation, a variety of technologies and methods exist to remove the two main pollutants, nitrogen oxides and sulphur oxides.

**Sulphur reduction technologies** Flue gas desulphurizers (FGDs), also called scrubbers, can reduce sulphur emissions by as much as 95 percent. There are a number of types of scrubbers. Dry Scrubbers use an alkaline substance, usually lime, to convert the sulphur in flue gas into a dry powder similar to fly ash.

Wet Scrubbers use an alkaline absorbent slurry (consisting of lime, limestone, magnesium-limestone, or even seawater, depending on the type of combustion chamber and the properties of the combustion gases). In a wet scrubber, the sulphur in flue gases comes into contact with the absorbent. The ensuing chemical reactions transform the sulphur into more benign substances. The end products of these processes vary. In the case of magnesium-enhanced limestone processes, the end product is commercial-quality gypsum.

**Nitrogen reduction technologies** As for nitrogen oxides, there are a variety of technologies that remove them from combustion emissions. These include low-$NO_x$ burners, which burn coal more completely so that nitrogen oxides do not have time to form. They also include selective catalytic reducers (SCRs), which operate in the same basic way as a catalytic converter on a motor vehicle: by converting nitrogen oxides into nitrogen, oxygen, and water.

Another method is Selective Non-Catalytic Reduction. Compared to other $NO_x$ removal technologies, SNCR is simple and easy to install in power plants. SNCR injects a chemical substance, such as ammonia or urea, into the flue gas. The system reduces $NO_x$ by breaking it down into three ingredients: nitrogen, carbon dioxide and water vapour. In certain temperatures, 30 percent of $NO_x$ can be reduced from flue gas using this process.

SNCR can be used in combination with other $NO_x$-reduction technologies, such as selective catalytic reduction.

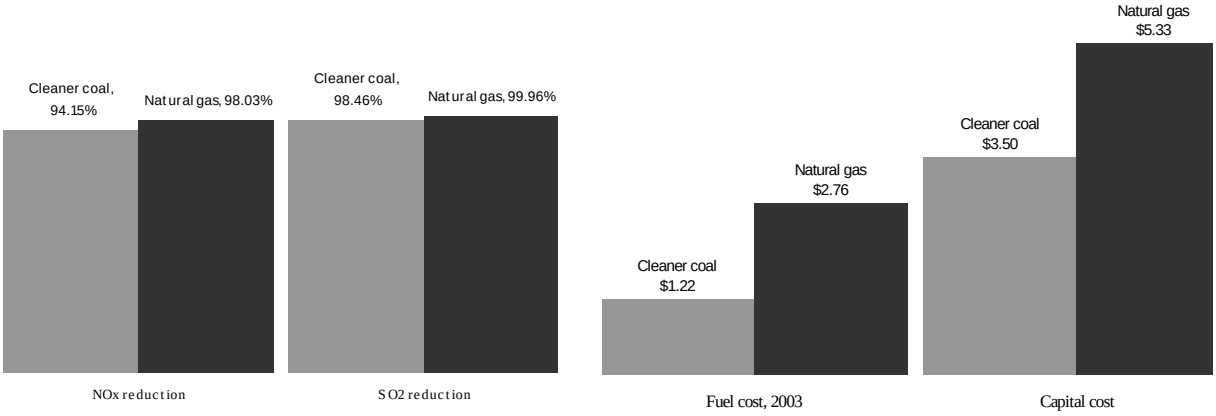
**Integrated Gasification/Combined-Cycle** Perhaps the most promising large-scale capture and treatment technology for coal generation is Integrated Gasification Combined-Cycle (IGCC) generation. In an IGCC plant, coal is converted to gas via a chemical process. The gas is then purified, during which many of the pollutants are removed. The final product, synthetic gas (primarily a mixture of hydrogen and carbon monoxide), is then burned in a conventional combined cycle generating plant. The result is combustion emissions that are lower than those of natural gas.

## Cost of cleaner coal technologies

What kind of sulphur and nitrogen reductions could we achieve using the devices and processes described above? And what would it cost, compared to a wholesale switch to natural gas? Fig. 15 on page 32 gives a good illustration. As you can see on the left-hand column chart, natural gas emissions do contain slightly less nitrogen and sulphur than cleaner coal emissions. But the right-hand chart shows that this slight reduction would be hugely expensive. It will cost $5.3 billion to build new gas plants. For nearly half that cost we could install cleaner coal devices that cut emissions by nearly as much.

Fuel costs of natural gas are even more alarming. As you can see in Fig. 15, natural gas fuel costs in 2003 were well over double those of coal. Few energy market observers believe gas prices will fall over the medium to long term. Most believe the tight continental gas supply

Fig. 15 **Emission reductions possible with cleaner coal and natural gas, and the cost (in $ billions) of achieving them[a]**




a. Reduction numbers were provided by Babcock and Wilcox; fuel and capital costs by Ontario Power Generation.

will result in chronically high gas prices.[33] Fig. 15 shows that the natural gas fuel cost in 2003 was more than $1.5 billion higher than that of coal. Over five years at these prices, the fuel bill alone for natural gas would be over $7.5 billion more than that of coal.

## Greenhouse gas reduction technologies

There are three major ways that individuals and organizations can reduce $CO_2$ emissions:

- Decrease "emission intensity"—using less fossil fuel to generate electricity.
- Carbon sequestration—capturing carbon from combustion emissions, and preventing it from getting into the atmosphere.
- Emission trading—in effect, paying another organization to reduce *its* emissions.

**Decrease "emission intensity"** The simplest way to reduce $CO_2$ emissions is to use less fossil fuel. In the transportation sector, the two main technological approaches to using less fossil fuel are hybrid gasoline-electric vehicles and hydrogen fuel cells. For the near term, it appears that hybrid vehicles, ones that incorporate both a gasoline or diesel engine with an electric-powered one, are more likely to become widespread.

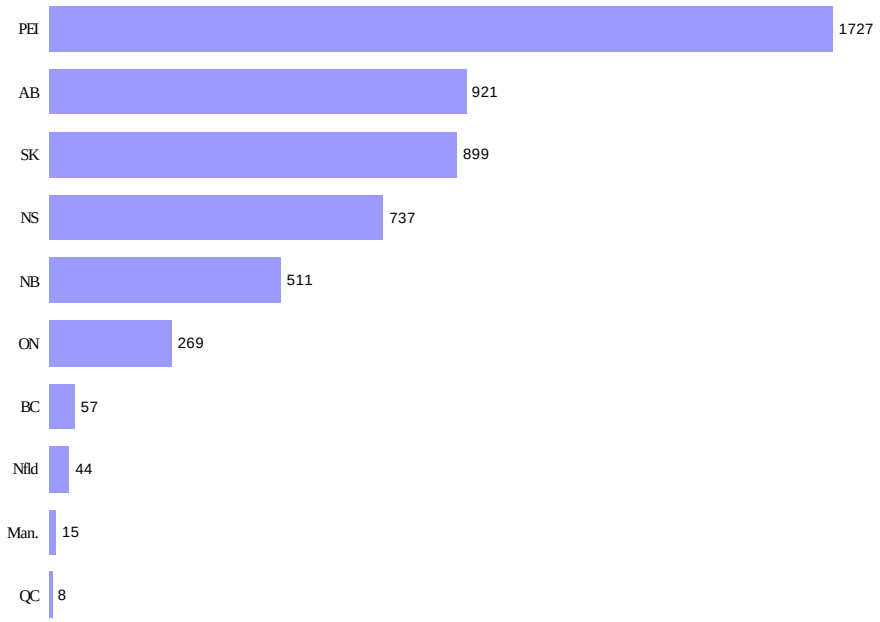
In the case of electricity generation, the best strategy is to reduce total system emissions, or at least reduce the emission intensity—i.e., the ratio of emissions, by weight, per watt hour—across the system. Currently in Ontario about three-quarters of the electricity comes from nuclear and hydro, which are carbon-free sources. The province's GHG emission inten-

33. The NYMEX price of natural gas broke US$10 per million Btu in late August 2005, even before Hurricane Katrina disabled gas rigs and production facilities on the U.S. gulf coast. The average price during 2003 was above US$5.50. (Source: "Natural gas hits high," *National Post*, August 25, 2005, p. A1; U.S. EIA.)

sity for electricity generation was roughly 269 tonnes per million kilowatt hours in 2001, as you can see in Fig. 16.[34]

Fig. 16 **Emission intensity for electricity generation in 2001, in tonnes per million kilowatt hours, by province**

Source: StatCan pub #57-001-XIB, "Electric Power Statistics," Vol. 70, No. 1; Environment Canada, "Canada's Greenhouse Gas Inventory 1990–2001."



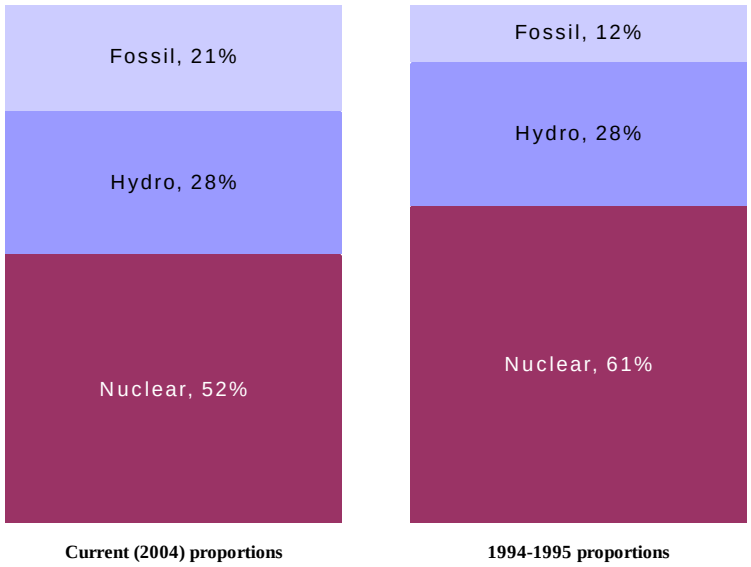

The only way to reduce the emission intensity is to increase the proportion of electricity generation from carbon-free or low-carbon technologies. The most practical alternatives to large-scale fossil fuel combustion include large hydro and nuclear. Ontario's large hydro resources are already exploited, but those in other provinces, such as Quebec and Newfoundland and Labrador, could hold considerable potential for the future.

However, it will be decades before these water resources begin generating electricity. So for the near- to mid-term, Ontario's best option is with nuclear power. In Ontario, this is a proven way of reducing $CO_2$ emissions. In 1994–1995, nuclear generation provided over 60 percent of the province's electricity needs (see Fig. 17). There was far less need to rely on coal to provide base load capacity (unlike the situation today). For this reason, coal emissions were less than half what they are today.

If Ontario were to return to the 1994–1995 generation mix, the electricity sector would be completely Kyoto compliant. It would be relatively easy to return to this mix. There are currently about 3,000 megawatts of laid-up nuclear capacity at the Pickering and Bruce generating stations. If the laid-up units returned to service, or if they were replaced with new

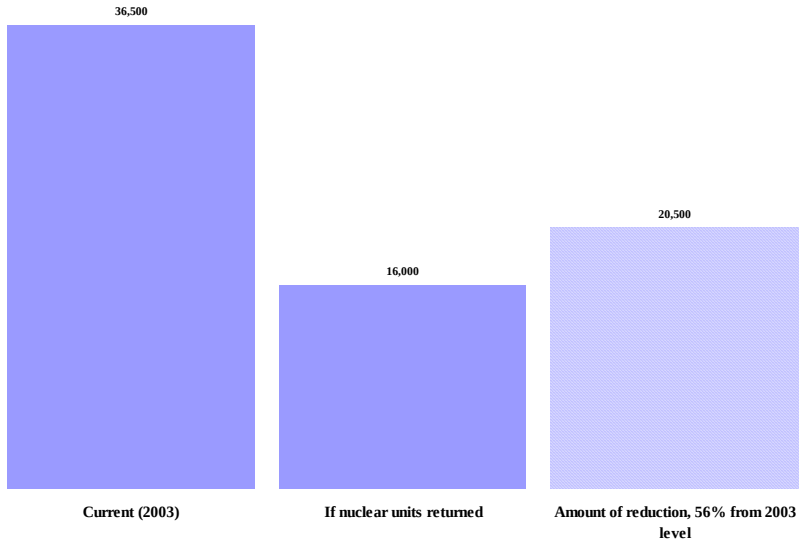
34. While Ontario's electricity sector emitted nearly 41 million tonnes of $CO_2$ in 2001 (second only to Alberta's 54.7 million tonnes) Ontario's emission intensity for electricity generation was near the lower end compared with most other provinces. Quebec's was by far the lowest, at 8 tonnes per million kilowatt hours. Prince Edward Island's 1,727 was by far the highest. New Brunswick's, Nova Scotia's, and Saskatchewan's were 511, 737, and 899, respectively. Ontario's emission intensity could drop to roughly 118 tonnes per million kWh if the province were to return to 1994–1995 generation proportions of 61 percent nuclear and 12 percent fossil; see Fig. 17.

Fig. 17 **Ontario's generation mix, current and 1994–1995**[a]




a. Current proportions are approximations, based on the 2004 figures given in OPG's "2004 Report," p. 11 and Bruce Power's Annual Report 2003, p. 29 (p. 16 of the PDF). Numbers are rounded. Fossil proportions in 2004 include output from the Lennox Generating Station, which is oil- and gas-fired, but not from non-utility generators (NUGS).

Fig. 18 **Greenhouse gas emission reductions, in kilotonnes, if returned to 1994–1995 generation proportions**[a]




a. OPG has not yet released its 2004 emission report. 2003 numbers compare Ontario Power Generation's reported 2003 $CO_2$ emissions (see "Annual Information Form for the Year Ended December 31, 2003," p. 22; p. 24 of the PDF) with Canada's total ghgs (see Environment Canada's ghg inventory, p. 4; p. 21 of the PDF).

nuclear generators, they could contribute some 20 billion kilowatt hours of electricity each year—electricity that coal is currently providing. Thus they could displace some 20 million tonnes of $CO_2$. (See Fig. 18.)

**Carbon sequestration** Another way to reduce $CO_2$ emissions is to prevent it from getting into the atmosphere in the first place. This is called Carbon Sequestration. An

easy way to make this happen is simply to let trees, algae, and other plants do the work: plants require $CO_2$ in order to photosynthesize. In large enough numbers, plants consume vast amounts of the gas. Hence the concern over tropical deforestation. Loss of forest cover has contributed 45 percent of the increase in atmospheric $CO_2$ since the 1950s.[35]

Another form, called physical sequestration, involves capturing $CO_2$ from flue gas and then storing it underground. While physical sequestration seems an expensive idea whose time is a long way off, a British scientist believes it will become more widespread within a decade.[36]

Indeed, there is much activity in this area. Research into ways to capture $CO_2$ from exhaust emissions is under way worldwide. A Canadian company, Cansolv Technologies, is currently demonstrating a process for capturing $CO_2$ from fossil fuel–fired boilers at an Abitibi Consolidated pulp and paper facility in Quebec. This demonstration project, which is partly funded by the Government of Canada, could prove to be a breakthrough in $CO_2$ capture, and could be directly applied to coal generation.

Another Canadian project, involving Suncor Energy and the Government of Canada, is looking at ways to inject captured $CO_2$ into deep coal seams in Alberta.

Another example of $CO_2$ capture is the "oxy fuel" technology being developed by Babcock and Wilcox. This technology concentrates $CO_2$ emissions in flue gas to enable easier sequestration. This technology also holds the promise of more efficient plant operation and a significant reduction in nitrogen oxide formation.

**Carbon trading** Another way to reduce system emission intensity is to purchase emission credits, through an emission-credit trading system. In effect, one emitting organization would pay a second organization to reduce the second organization's emissions. (The Kyoto Treaty encourages emissions trading for exactly this purpose.) Ontario Power Generation began participating in the nascent emission-credit trading system in 1997, when it purchased credits from DuPont Canada, after DuPont achieved dramatic GHG reductions at its manufacturing plant in Maitland, Ontario.

35. Ian Swingland, ed., *Capturing carbon and conserving biodiversity: the market approach*, The Royal Society 2002, p. 15.

36. Dr. Jon Gibbins of the Carbon Capture and Sequestration Consortium, quoted in the *Financial Times of London*, March 3, 2005.

# Ontario's influence on U.S. environmental policy

THE ONTARIO GOVERNMENT HAS EXPRESSED ITS BELIEF that closing the province's coal plants will signal good faith to neighboring U.S. states in subsequent negotiations on trans-boundary air quality.[37] Perhaps the government believes its U.S. counterparts will follow suit and close down their own coal-fired generating plants.

However, in view of coal's importance to the U.S. power generation system, it is not likely that this will happen. It appears very likely that American generating companies will continue to expand coal generation capacity. They will deal with CAC emissions by using the control devices described on page 30, and offset the $CO_2$ emissions with nuclear generation, which is carbon-free.

Coal currently produces more than half of America's electricity. North American coal reserves are abundant. At current usage rates, they will last for another two and a half centuries. Secure supply and low costs for coal mean that U.S. utilities will continue to rely on it. Indeed, there are currently plans to expand U.S. coal-generation capacity by 40,000 megawatts.

American jurisdictions face the same environmental pressures as Ontario. The U.S. federal government approach has been generally to maintain reliance on coal but to curtail emissions through clean air regulations monitored and enforced through the Environmental Protection Agency (EPA). American utilities tend to comply with EPA regulations by using emission-control methods and technologies similar to those with which Ontario Power Generation has cut its own coal emissions to less than two-fifths of the 1983 levels.

If Ontario abandons coal in favour of natural gas, the price of which has been high and volatile, this will expose Ontario industry to higher and more volatile electricity costs in a manner that will not be experienced by our closest geographic competitors.

In light of this, Ontario's good-faith move on coal generation will only result in greater disparity between Ontario electricity prices and those in competing U.S. jurisdictions. This disparity is already significant.[38]

Moreover, because more than half of the air pollution in Ontario is attributable to pollution from the U.S., particularly during the summer months,[39] increased electricity production in adjacent states of the U.S. may create additional pollution that affects Ontario. Ironically, the Ontario government's coal shut down policy could drive electricity prices so high in this province that it becomes more economical to import coal-generated electricity from the U.S.

37. An Ontario Ministry of Energy presentation to the Calgary Chamber of Commerce in August 2004 said "experience with the acid rain program suggests that Ontario will have to reduce its own emissions before we ask the U.S. to reduce their emissions." (Source: "Ontario's Electricity Sector," slide 13.)
38. According to the results of an industry survey, Ontario's industrial electricity prices are already the fourth highest of 24 competing North American jurisdictions. Eliminating coal and switching to natural gas will drive Ontario rates even higher. (Source: Association of Major Power Consumers in Ontario.)
39. See Fig. 6 on page 17.

## Smart leadership on trans-boundary air quality

If the Ontario government wants to lead by example, a better example would be to finish the cleaner coal implementation at Ontario coal plants. Currently, only six of the fourteen coal-fired generating units are equipped with any kind of emission-control devices. Of these six, only two are designed for sulphur removal.

Given the impressive reductions already achieved through this partial implementation (see Fig. 14 on page 30), further dramatic reductions under a full implementation are a certainty. Cross border cooperation on air quality measures would prove far more effective if the government were to adopt this course.

Finishing the cleaner coal implementation at Ontario's coal plants would set a powerful example not only with our American neighbours, but also with other Ontario emitters. As mentioned, the Ontario government is already encouraging heavy emitters in this province to adopt emission control methods and technologies similar to those already in limited use at Ontario coal plants (see Footnote 31 on page 30). Other Ontario emitters would greatly benefit from these best practices, and benchmarking these best practices could ensure successful implementation in other industries.

This approach would prove far more effective and realistic than a high-minded but futile rush to eliminate coal from the generation mix. It would also dovetail with intensive international efforts to make coal a cleaner fuel. Major coal burning countries such as the U.S, U.K., Canada, and Australia are working on making coal one of the cleanest energy sources available and even extracting additional value from the products of combustion. For example, the U.S. Department of Energy has a billion dollar, multi-year project to develop a coal fired generating plant with zero emissions, including carbon dioxide. Canada has its own prototype coal gasification project.

# A Renewable Electricity Future for Ontario

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A Senior Honours Thesis Submitted in Partial Fulfillment of the Degree of Bachelor of Environmental Studies (Honours Environment and Resource Studies/Geography)

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# Abstract

The provincial government's recent commitment to phase out coal burning generators by 2007, and the questionable future of Ontario's aging nuclear reactors, raises serious uncertainties about the supply of electricity to the citizens of Ontario. Rather than simply replacing coal and nuclear facilities with alternative carbon based fuels sources, this paper suggests that much of Ontario's electricity requirements could be met through aggressive efficiency initiatives and renewable sources of generation. Both local as well as global examples have illustrated the tremendous potential for, and benefits of, efficiency initiatives and renewable production. The advantages include: security of supply, adequacy, affordability, reliability, environmental soundness, and preservation of economic competitiveness. Yet while it seems that many of the problems with Ontario's electrical energy generation sector are beginning to be recognized, and measures put in place to address the issues, policy recommendations thus far have not led to concrete and enforceable legislation. The focus seems to be more on balancing consumer satisfaction and industry demands than on implementing aggressive, long term and truly sustainable policies. Addressing this problem may require incorporating a holistic framework that recognizes efficiency initiatives as both possible and desirable, that acknowledges renewable generation as preferable to traditional generation, and that seeks diverse, highly adaptable and ultimately more sustainable policy decisions.

# 1.0 Introduction and context

The blackout of August 14, 2003 caused traffic jams, medical emergencies, work stoppages and numerous other socio-economic disturbances ranging from minor inconveniences to major lifestyle alterations. Yet despite such occurrences, the blackout may actually have been a blessing in disguise. Electricity in Ontario had "energized mass culture and mass experience to such an extent that it had become like the air, something you only miss when it's no longer there" (Swift & Stewart, 2004, p.32). By forcing Ontarians to ponder their dependence on electricity and by exposing the vulnerability of Ontario's electricity system the blackout served as a wake up call. It forced the provincial government to re-examine the stability of its electrical power grid. It forced citizens to examine their individual user-ship and take stock of how they over-use electricity. But perhaps most notably, the blackout raised questions about what other options might be available to the province and forced all Ontarians to consider the future of the province's electrical energy system.

Ontario currently draws the majority of its electricity from three sources: nuclear (approx. 40%), coal (approx. 25%) and hydro (approx. 25%). With the provincial governments recent commitment to phase out coal burning generators by 2007, and the future of Ontario's aging nuclear generators questionable at best, serious uncertainties about the supply of electricity to the citizens of Ontario exist. To add to Ontario's electricity woes, the province has one of the highest per capita energy demands in the world. These problems, and the uncertain future they present, have spurred questions about what approaches are available and how the province should make its choices in order to supply its residents with electricity now, and for years to come.

This paper will examine what options, or packages of options, are viable for a sustainable electricity future in Ontario as well as what the proper criteria for evaluating those options may be. These primary goals will involve several key methodological research steps each translated into a separate report section. The first such section will involve a survey of the various issues surrounding energy and electricity in Ontario including the current decision making process. Afterwards the various supply and demand side options available for Ontario will be summarized and compared. Next, the options and implementation mechanisms will be analyzed and compared against a set of "sustainability" oriented decision making criteria. Finally conclusions will be made about the most feasible packages of options and the most appropriate concepts to be involved in their evaluation.

Much has happened in Ontario since the blackout. New government commitments and pricing changes have been implemented, demand side management has been promised and there

seems to have been recognition of the looming problems facing Ontario's electricity sector. Now is the time, especially in light of all that has transpired over the past 18 months, for Ontario to begin to examine its options for a sustainable electricity future.

## *1.1 Background and significance of this issue*

### 1.1.1 Energy Supply and Demand Issues:

The problems associated with the supply and demand of electricity are global in scope. While in Ontario citizens, organizations and government officials ponder pricing mechanisms and debate which path to follow, "two billion people, some 70 percent of the developing world, have no access to electricity" at all (Milburn, 1996, p.4). Sayigh (1999, p.29) adds that "there is an enormous gap between supply and demand with one third of the world population being without". Such widespread disparity is an enormous problem as "access to electricity services is widely perceived to be an important ingredient to economic development" (Kozloff, 1995, p.215). While this study will focus on energy policy options in Ontario it is important to acknowledge that electricity supply and demand is truly a global issue.

Global energy consumption is primarily drawn from six sources: 44% petroleum, 26% natural gas, 25% coal, 2.5% hydroelectric power, 2.4% nuclear power and 0.2% non-hydro renewable energy (Chow, Kopp & Portney, 2003, p.1528). Most of these conventional means of energy production (and associated consumption) "are closely linked to environmental degradation [that] threatens human health and quality of life, and affects ecological balance and biological diversity" (UNDP, 2000, p.9). Predominant current sources of energy are ultimately unsustainable as they are primarily derived from non-renewable resources and have significant and long lasting environmental impacts. Such impacts are illustrated by the United Nations Development Programme (2000, pp.10-11) which has stated that at "every level (local, regional, global), the environmental consequences of current patterns of energy generation and use make up a significant fraction of human impacts on the environment". Yet with few exceptions nations around the globe remain committed to conventional sources of power. It seems clear that the predominant energy systems "are not addressing the basic needs of all people, and the continuation of business-as-usual practices may compromise the prospects of future generations" (UNDP, 2000, p.2).

The issues surrounding energy supply and demand, as well as their presence in the global decision making arena, have evolved a great deal over the past three decades. The first steps, though incremental, towards a more sustainable electricity future were made at the United

Nations Conference on the Human Environment (UNCHE) in Stockholm. Although "little was said…regarding issues related to energy", the Stockholm Action Plan did contain three recommendations that do deal with energy. These three recommendations "call merely for better data collection and analysis" (Najam & Cutter 2003, p.126). The limited scope of such recommendations is not surprising considering that the conference occurred before the major oil price shock of the 1970's and in an era before global climate concerns had fully emerged. Despite this, "the conference was an attempt to turn the environment into a more 'global' issue" (Najam & Cutter 2003, p.125) and therefore proved significant.

A full twenty years after the Stockholm conference came the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro. At this conference, through a document titled Agenda 21, "the United Nations and its member states… strongly endorsed the goal of sustainable development, which implies meeting the needs of the present without compromising the ability of future generations to meet their needs" (UNDP, 2000, p.2). Compared to UNCHE the UNCED was "more precise and prescriptive…highlighting the need for decreasing consumption, increasing efficiency and transitioning to cleaner sources" (Najam & Cutter 2003, pp.129-130). Although "some consider the summit to have failed its potential…most commentators and experts consider this Summit to have been a success in terms of elevating the global profile of environmental issues and raising awareness regarding sustainable development" (Najam & Cutter 2003, p.127). In addition to broadening the scope of the global environmental forum by embracing the concept of sustainable development this conference served to raise public interest of major sustainability issues such as global climate change and fossil fuel use and paved the way for later documents such as the Kyoto Protocol as well as what would follow in the World Summit on Sustainable Development (WSSD) in Johannesburg. The WSSD was the first conference to "clearly [deal] with energy as an issue in its own distinct right rather than as a facet of other issues" (Najam & Cutter 2003, p.131). After thirty years of dialogue surrounding global environmental policy and sustainable development the WSSD began to make steps towards implementing a global vision of sustainability in regards to energy.

In terms of energy supply, an initial analysis of the situation may lead one to believe that few if any problems exist with current usage patterns. After all, "analysis of the long-term availability of energy resources, starting with conventional and unconventional oil and gas, indicates that these resources could last another 50–100 years—and possibly much longer" (UNDP, 2000, p.12). However, closer examination reveals that serious energy supply issues are looming in the not too distant future. For example "if the global growth rate of about 2 percent a year of primary energy use continues, it will mean a doubling of energy consumption by 2035 relative to 1998,

and a tripling by 2055" (UNDP, 2000, p.5). To add to this situation Salameh (2003, p.34) points out that "the world is consuming nearly four times more oil than it is finding, a situation that is ultimately unsustainable". In addition to the currently anticipated supply issues, based on current demand patterns "energy consumption in developing countries is expected to catch up with that of the industrialized world in the first quarter of [this] century" (Milburn, 1996, p.4). In countries like India and China "population growth and rising economic activity [will] lead inexorably to accelerating electricity demand" (E7, 2003, p.3). Dyer (2004) adds that the situation the world faces is "a demand shock" and because of the "rapid economic growth of China and India, there is now a market for every barrel of oil that the producers can pump. Future demand is likely to grow faster than future supply for exactly the same reason". The overwhelming challenge of the 21st century may be that while "demand for electricity continues to grow largely unabated … society is divided on how to generate new power" (David Suzuki Foundation, 2003, p.7).

In Canada the situation is much the same. Some have predicted that Canada's electricity needs over the next 50 years will increase by between 60 and 270 percent (Clean Air Renewable Energy Coalition [b], 2004 p.2). In Ontario the per capita consumption of electricity has "increased by close to 1 per cent per year for the past quarter-century" (Anonymous [a], 2004). In comparison the state of California's per capita consumption has increased merely one percent in total over this same time frame despite a growing population because of the states commitments to efficiency and conservation through education and policy initiatives. Such growth has resulted in a province that, aside from Quebec, consumes "more energy per capita than anywhere else in the world" (Anonymous [a], 2004).

In addition to ongoing questions related to the quantity of Ontario's energy supply there are also many concerns surrounding the traditional energy sources used to generate most of the province's electricity, their ability to meet the province's demands and their overall sustainability (see figure 1.1).

***Figure 1.1 Energy Supply in Ontario (2003)***

| SOURCE | CAPACITY | % of TOTAL |
|---|---|---|
| Nuclear | 10800 MW | 39.4% |
| Fossil Fuels | 9700 MW | 35.4% |
| Hydroelectric | 6796 MW | 24.8% |
| Green Power * | 134 MW | >1% |
| **Total ** ** | **27430 MW** | **100%** |

* composed of 29 hydroelectric and three wind sources.
**Ontario's peak electricity demand is approximately 25,000 megawatts
Source: (Ontario Power Generation website)

Ontarians have good reason to be concerned. The province is barely meeting its electricity requirements as is and with demand expected to grow, in a system dependent upon aging nuclear reactors and coal power plants that are intended to be phased out by 2007, supply shortages may be immanent. Such shortages are "a threat to economic activity and business confidence, not to mention public health and safety" (David Suzuki Foundation, 2003, p.7). The province is in desperate need of an energy strategy that will meet the current needs of its population and meet the sustainability goals of the province, nation and global community.

In order to evaluate Ontario's electrical energy future a full range of sustainability criteria must be considered. Sustainable development traditionally refers to development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p.8). Such development "relates to three critical elements that need to be treated together: economic, social and environmental" (Banuri et al. in Najam & Cutter 2003, p.118). Economically, energy supply is directly related to macroeconomic growth throughout the world. Environmentally, conventional energy sources have in no small part contributed to ecological stress including global warming at both global and local levels. Lastly, energy is directly related to "a range of social issues, including poverty alleviation, population growth, urbanisation, and a lack of opportunities for women" (UNDP, 2000, p.7). Najam and Cutter (2003, pp.118-119) add that "energy is a prerequisite for the fulfillment of many basic human needs and services, and inequities in energy provision and quality often manifest themselves as issues of social justice". In evaluating the options it is important to note that the generation of electricity not only affects the traditional economic, ecological and social dimensions of sustainability individually but also requires a holistic view of how these components interact with one another.

Overall, based on current trends, it seems that the demand for electricity in developing economies is certain to grow. What remains to be seen is what sources of energy will be sought after as developing economies continue to grow and as the economies of developed countries like Canada address lingering supply issues. Another uncertainty is whether or not efficiency and conservation will be integrated into future energy policies throughout the world.

## *1.2 Exploring the Issues*

While it is beginning to be recognized that a successful energy policy for Ontario must incorporate sustainability criteria in to decision making, until now the province's electrical energy policy has not always reflected this. Efficiency and conservation strategies began to emerge early in the 1970's when "oil embargoes, rising energy prices and increased pollution raised

concerns about continued dependence solely on fossil fuels" (Silverman & Worthman, 1995, p.14). However, many energy saving initiatives in Ontario were "set aside in Ontario during the period of deregulation and government downsizing in the middle of the late 1990s" (David Suzuki Foundation, 2003, p.25). Meanwhile, the majority of electricity policy decisions in Ontario have been based around supporting large energy projects and "building new capacity rather than aggressively seeking energy efficiencies" (David Suzuki Foundation, 2003, p.9). Critics have pointed out that to answer the call of rising demand the province's strategy has been to "simply boost supply by importing coal-fired electricity" and to bring mothballed nuclear reactors back on line at extravagant costs (David Suzuki Foundation, 2003, p.1). For example, the province's coal fired power plants have been increasing supply and recently the Pickering A as well as two more generators at Bruce nuclear power plant returned to service. Many believe that the province's money would have been much better spent on investments in energy efficiency programs and conservation (Torrie & Parfett, 2003; Suzuki, 2004; Daly & Cobb, 1994).

Despite this history of supply side management and its lack of sustainable forethought, recent announcements from the federal and Ontario governments provide some reason for optimism. At the national level Prime Minister Paul Martin (in his speech from the throne) committed to an "increased focus on energy efficiency research and development…[in addition to] developing comprehensive approaches to encourage increased production and use of clean, renewable energy and to promote greater energy efficiency" (Martin, 2004). In Ontario, Energy Minister Dwight Duncan has acknowledged that the province must make a 25 to 40 billion dollar investment in new generating capacity "to keep the lights on over the next 15 years" (Anonymous [a], 2004). He also committed to phase out coal power in Ontario by 2007. To add to the promises made by government officials, Ontario's currently proposed electricity restructuring bill proposes setting aside 225 million dollars for local utilities to promote conservation (Mills, 2004). The provincial government has also set a target of a five percent reduction in demand by 2007 and as Spears (2004 [c]) highlights "has issued a request for proposals to add 2,500 megawatts of generating capacity or demand reduction". In addition the Ontario Ministry of Natural Resources issued a request for proposals for both the development of an Ontario wind energy map and initial proposals of 300 megawatts of new renewable generating capacity.

While such announcements show signs of promise, many believe that Ontario's overall electricity policy still lacks the vision needed to meet the province's upcoming supply challenges. For example, "Ontario's aging nuclear reactors, which supply more than 40 per cent of the province's power… will need to be replaced or refurbished by 2020" (CWEA a/b, 2004). With

such looming supply problems Duncan's conservation target of a five percent reduction over three years is considered by some to be extremely modest, especially compared to what has been achieved in places such as California (where efficiency initiatives and conservation have reduced the need for new generation by 3,600MW). Similarly the province's commitment to add 300 MW of additional renewable energy to the grid would account for approximately one percent of the province's overall demand. This goal seems to be timid given that industry experts suggest that wind energy alone could meet as much as 20 per cent of the province's energy requirements (Daniszewski, 2004) and considering that the province's request for proposals "triggered responses totalling 4,400 megawatts" (Spears, 2004 [c]). While Canada has seemingly recognized the severity of the climate change threat through actions such as the ratification of the Kyoto Protocol in 2002, little concrete improvement has been achieved. If Canada is to meet its Kyoto commitments (to reduce emissions of greenhouse gases to 6 per cent below 1990 levels or 25 per cent below today's levels) action towards a sustainable future must be taken now before it is too late. The province can and must do more if it is to achieve a sustainable future.

Ontario's goal must be to develop an electrical energy strategy that meets the needs of current generations without compromising the needs of future generations. Meeting these demands will require "major improvements in the efficiency of energy use, a much higher reliance on renewable energy technologies, and cleaner and safer fossil fuel technologies" (UNDP, 2000, p.433). Such a strategy should "support both human and ecosystem health over the long term" (UNDP, 2000, p.11) and will require steadfast political commitment in addition to the dedication of more resources to this worthy cause. As Scheer (2004) suggests "it is high time we spent as much effort politically, scientifically, and technologically on the development of renewable energy as we once did on nuclear power". In addition to dedicating resources to new renewable sources, efficiency and conservation must be aggressively promoted as a "viable technical option that provides significant social and environmental co-benefits" (David Suzuki Foundation, 2003, p.25). Combining the promotion of renewable electricity sources and efficient use is ultimately the only sustainable electricity path for Ontario to follow.

## *1.3 Examining the Options – Evaluation Criteria*

One of the primary goals of this study is to provide a set of sustainability based evaluation criteria factors for the province's electrical energy sector. While the term sustainability and its main components are now widely understood and accepted, most decisions made thus far in Ontario have, in application, left something to be desired. The traditional approach to sustainable decision making has been to acknowledge and incorporate each of three (ecological, economic

and social) disciplinary "pillars". While this approach does incorporate notions of sustainability, it has generally "proved more useful for categorizing and separating than for linking and integrating" (Gibson, 2004). In order to be truly useful the criteria developed in this study must recognize that "the most difficult and most crucial issues are about cross-category concerns in a world of connections and interdependencies" (Gibson, 2004). Acknowledging and implementing this element of sustainable thinking into the evaluation criteria increases the chances of a sustainable electricity future in Ontario.

While it is likely the case that no one set of sustainability criteria can be universally applied to any given situation there are guiding principles that should be incorporated into future decision making. By embracing a broader sustainability agenda Gibson (2004) suggests that "we can recognize complexity and uncertainty, accept the importance of context and the likelihood of conflict, and still agree that we should always think carefully and openly about our bases for decision making, and keep decision criteria visible and available for debate" (Gibson, 2004, p.2).

## *1.4 A Sustainable Future*

Developing and adhering to a set of sustainability based decision making criteria increases the likelihood of a desirable electricity future for the province. However, this goal also depends heavily upon "attitudes and behaviour, information and technologies, the availability of finance and supporting institutions, and - in particular - policies and policy frameworks that encourage change in the desired direction" (UNDP, 2000, p.24). Such policies may be as straightforward as stimulating markets for green electricity and efficiency. Nevertheless it is likely that, in addition, "targeted government policies and consistent regulatory approaches will be needed. (UNDP, 2000, p.24). Promoting a sustainable electricity future for the province will ultimately be in the hands of governments, corporations, international institutions as well as the general public. If appropriate measures are not taken in a timely fashion, windows of opportunity which have remained open until now are likely to close, potentially forever.

Whether or not a sustainable future is possible for Ontario's electricity sector is uncertain. Some believe that "combating global warming by radical restructuring of the global energy system could be the technology challenge of the century" (Hoffert et al. 2002, p.982). The transition to sustainability involves the phasing out and replacement of traditional fossil fuels and nuclear power with non-polluting green energy sources. While such a transition is bound to take time, forecasts suggest that "over the next 20 years the amount of primary energy required for a given level of energy services could be cost-effectively reduced by 25–35 percent in industrialized countries (UNDP, 2000, p.13). The degree to which such reductions occur will

depend on political will, leadership and the implementation of effective policy frameworks and measures (see figure 1.5). It will require cooperation between nations as well as between the various levels of government within Canada. Finally it will require changes in the prevalent attitudes and behaviours and a shift towards energy conservation.

***Figure 1.5: Key Roles of Ontario Provincial Government***

| **Establish targets and goals:** |
|---|
| • Develop a comprehensive electrical energy policy for Ontario that emphasizes renewable energy and fulfills sustainability objectives.<br>• Announce a clear efficiency goal – e.g. 20% reduction in province wide electricity use by 2010 (both short and long term goals). |
| **Financial incentives and market conditions:** |
| • Commit to a package of long term, broad based aggressive incentive programs for both consumers and producers to promote energy efficiency.<br>• Invest in renewable energy technologies.<br>• Provide financial incentives – through subsidies, grants, tax breaks, guaranteed markets, favourable pricing or though disincentives such as carbon tax.<br>• Establish market conditions that are transparent and encourage investment. |
| **Education:** |
| • Implement a province-wide public education campaign to promote conservation and efficiency strategies. |
| **Research and development:** |
| • Provide government funded investments in research and development of renewable electricity technologies (both supply and demand oriented). |
| **Decision making:** |
| • Implement transparent and collaborative planning processes.<br>• Incorporate environmental assessment into decision making process.<br>• Create an energy efficiency fund to support demand side initiatives.<br>• Introduce regularly updated standards programs to ensure the highest electrical efficiency.<br>• Establish a renewables portfolio standard – e.g. 10% by 2010<br>• Work with all levels of government in developing a national energy efficiency strategy, effective efficiency measures and support of Kyoto initiatives. |

Sources: (Ellis and Peake, 1996), (David Suzuki Foundation, 2003) and (Clean Air Renewable Energy Coalition [b]. 2004)

It is the primary goal of this study to discuss Ontario's electricity options, examine appropriate mechanisms of implementation and apply a set of evaluation criteria that may be used to contribute to a sustainable electrical energy policy. Such a policy should be harmonious with the overall ecological, social and economic structure and objectives of the province and nation.

# 2.0 - The Ontario Electricity Experience

Ontario has a long history of electrical energy generation that dates back to the turn of the century. The goal of policy makers in the province has historically been to supply the province with "cheap and abundant" power. Nevertheless, occurrences such as the blackout of 2003 have highlighted the fact that the province faces supply shortages in the not too distant future if serious action is not taken. Recent provincial announcements show signs of promise yet Ontario's overall electricity policy still lacks the vision needed to meet the province's upcoming supply challenges. Numerous policy options involving a variety of supply and demand side initiatives exist. The means of achieving such ends can, in general, be broken down into three groups: (1) mandatory requirements, (2) labelling, certification and education, and (3) fiscal incentives and research and development funding (see table 2.1). For Ontario to achieve a sustainable electricity future the province must develop an electrical energy strategy that meets the needs of current residents without compromising the needs of future generations.

***Table 2.1 Policy Options for Sustainable Electricity***

| Mandatory Requirements | Labelling, Certification and Education | Fiscal Incentives and R&D Funding |
|---|---|---|
| • Renewable Portfolio Standard<br>• System benefits charges<br>• Net Metering<br>• Emissions Standards and Trading<br>• Guaranteed Prices<br>• Renewable Energy Certificates | • Certified Green Electricity<br>• Premium Green Pricing<br>• Education Campaigns<br>• Conferences and workshops<br>• Voluntary Agreements | • Production tax credit/incentive<br>• Investment tax<br>• Incentives<br>• Tax exemptions<br>• Emission tax<br>• Tradable permits<br>• Increased government funding |

Adapted from: (Clean Air Renewable Energy Coalition [c]. 2004)

## *2.1 Evolution of Electricity sector and policy in Ontario*

Ontario's electrical energy infrastructure and political vision began to take shape just after the turn of the 20th century. The early days of electricity generation saw, now famed politician, Sir Adam Beck at the helm with his vision of inexpensive and reliable power for all of Ontario. Although no one knew it at the time, such principles would become the predominant and pervasive political ideology for electricity generation for many years to come. Ontario's energy foundations (based primarily on hydroelectric generation) were developed by the Ontario Hydro-Electric Power Commission (HEPC), a government run enterprise, that was able to offset the high costs of such an endeavour by drawing subsidies from the province's sufficient tax base. The HEPC operated from 1906 until 1973 when it was renamed Ontario Hydro. For most of a century

this government run monopoly did an adequate job of providing Ontario with inexpensive and readily available electrical energy. However, by the 1990's, despite a history of supply side management, the Province began to question its electricity resources.

The year 1995 brought a new political party into power in the province and a new outlook on its electricity future. The Progressive Conservative party began to examine the electricity market in Ontario and proposed, based on their 1996 Macdonald Commission and 1997 White Paper, that Ontario Hydro be disassembled and the electricity market be opened to private competition. They believed, based on what had occurred in other jurisdictions around the world, that a competitive market would produce the best prices and encourage necessary private-sector investments in future generation assets (Hampton, 2003). However, before such recommendations would come to be several delays and structural changes would take place.

The implementation of 1998's Energy Competition Act in 1998 divided Ontario Hydro into five agencies: OPG, Hydro One, the Independent Electricity Market Operator, Ontario Electricity Financial Corporation, and the Electrical Safety Authority. The Energy Competition Act also legislated the introduction of competitive retail and wholesale electricity markets; however, such policies would not actually take effect until May of 2002. Until this time Ontario Hydro had been responsible for planning and meeting the provinces electricity generation needs. The new legislation exposed the province to competitive markets intended to "rely on the private sector to plan for and develop electricity supply n response to the province's needs" (Winfield et al, 2004, p.1). What transpired over the following six months was not what the politicians had envisioned. Prices rose significantly and were extremely volatile. Following the Enron scandal in the US, market conditions and investor confidence was shaky at best and little private sector investment occurred. As a result, a mere six months after the market was opened to competition, Premier Ernie Eves and the Provincial government terminated the new legislation, "adopted a fixed electricity price of 4.3 cents per kWh, retroactive to May 1, 2002, and stated that this price would stay in place for the following six years" (Winfield et. Al, 2004, p.1). While this decision stabilized prices for consumers and was a politically popular decision it made Ontario's electricity problems worse. Policy swings such as these reflected the province's lack of vision and sustainable foresight. Electrical energy policy that had seen more changes over the past decade than it had in the previous century was creating an overwhelming atmosphere of uncertainty and confusion.

### 2.1.1 Kyoto Issue Overview

Much of the recent policy debate surrounding electricity has had to face concerns about global warming. As far back as the 1980s scientific evidence began to link global warming with the burning of fossil fuels such as oil, gas and coal. Concerned scientists launched a series of international conferences to attempt to address the problem. One of the first such conferences was The World Conference on the Changing Atmosphere (WCCA), held in Toronto, Ontario, in 1988. The WCCA brought together scientists from 46 countries who collectively called for an international treaty on climate change. This call was answered when in 1992 the United Nations Framework Convention on Climate Change (UNFCCC) was finalized as an international treaty. In December of 1992 then Prime Minister Brian Mulroney led Canada to be one of the first nations to ratify this agreement. However the UNFCCC was based mainly around voluntary emission reduction commitments and it was soon realized that it lacked the legal requirements needed to force changes. Such a document, which would be known as the Kyoto Protocol, was finalized and signed in 1997. This document is "a legally binding agreement to cut greenhouse gas emissions under the UNFCCC" (Suzuki, 2004). The Kyoto Protocol "encourages countries around the world to move to more environmentally responsible ways of producing and using energy, in order to meet their targets for emission reductions… [and] is the first binding international agreement on climate change that is global both in aim and effect" (Suzuki, 2004).

On December 10, 2002, Prime Minister Jean Chrétien ratified the Kyoto Protocol. In doing so Canada agreed to reduce its greenhouse gas emissions by six percent below 1990 levels by a target period of 2008 to 2012. With Russia's recent signing of the Protocol Canada is now officially legally required to meet these targets. However, thus far, despite incremental improvements, Canada seems to be destined to fall well short. The Canadian strategy for "meeting our emission reduction targets is expected to include mandatory emissions cuts and an emissions trading system for large factories and power plants; updated standards for more energy efficient buildings, homes, vehicles and appliances; financial incentives for smaller businesses to cut their emissions; and tax breaks and financial support for public transit and alternative fuels" (Suzuki, 2004). While Kyoto emission reductions will come from a variety of sectors, the electricity sector will compromise a significant portion.

Kyoto initiatives seem to focus primarily on what can be accomplished in the relatively near future (i.e. 2008-2012). As such "the preferred solutions are those, such as energy efficiency, that can deliver the targeted greenhouse gas emission reductions over the next few years at the least cost" (Rowlands, 2003, p.19). While such goals are needed, and certainly admirable, they fall

well short of the initial UNFCCC goals of emission reductions approaching 60 to 80 percent below 1990 levels or about 1 billion tons annually that would stabilize the earth's climate (Brown et al., 1991). As Rowlands (2003, p.19) points out "the Kyoto Protocol demands only limited changes to what remains a carbon-based economy and society". To achieve a truly sustainable electricity future in Ontario will require much more commitment to renewable electricity generation than has been seen thus far.

## *2.2 Actors/Advocates*

### 2.2.1 Government

In Canada, section 92A of the Constitution Act states that each province has "exclusive jurisdiction over the development, conservation, and management of its non-renewable resources, which have been interpreted to include energy resources…and hydro electric power facilities" (Field, 1995, p.279). Therefore, officially, the primary responsibility within Ontario falls upon provincial Ministries including Energy, Environment, Finance and Natural Resources. With that said, Field (1995, p.279) points out that it is often the case that "the regulation of specific environmental problems in Canada tends to be done at both the federal and provincial levels". Such an arrangement makes sense: while Ontario's energy resources fall under provincial jurisdiction, the by-products of electricity generation such as atmospheric pollution are of a National and indeed global concern.

### 2.2.2 Power Producers and Operators

Prior to the Energy Competition Act of 1998 electrical energy production in the province was controlled almost exclusively by Ontario Hydro. The act however served to divide Ontario Hydro into four separate entities each with different roles. Ontario Power Generation (OPG) now controls the generation and sale of electricity within the province. Hydro One is responsible for the distribution and transmission system in Ontario. The Ontario Electricity Financial Corporation (OEFC) is the legal remnant of Ontario Hydro and provides financial services, such as managing the outstanding debt from Ontario Hydro, and calculating financial risks. Finally, the Electrical Safety Authority is responsible for all electricity safety matters. In addition to these four entities are other private firms such as the Cameco corporation which owns nearly one third of the Bruce nuclear facility, municipal power authorities that distribute electricity and the Independent Electricity Market Operator (IMO) which manages the Ontario electricity market and analyzes figures based on provincial demand as well as other market data.

### 2.2.3 Lobbying and Interest Groups

A great many organizations and special interest groups have voiced concern over the future of Ontario's electricity system. The following list includes some of the most prominent groups:

- Sustainable Energy Association
- Canadian Wind Energy Association
- Ontario Clean Air Alliance
- Clean Air Renewable Energy Coalition
- Canadian Institute for Environmental Law and Policy
- Canadian Association for Renewable Energies
- The Pembina Institute
- David Suzuki Foundation
- Additional Industry Consumer Groups

## *2.3 The Ontario Supply and Demand Situation*

### 2.3.1 Current Status

Ontario requires approximately 20-25,000 MW of power at any given time (Spears, 2004 [c]). The current limits of the Ontario power supply grid are being flirted with, yet Ontarians continue to consume more power per capita than nearly anyone else in the world. One reason for this is that in Ontario electricity prices have been heavily subsidized. For example, in November of 2002 the Ontario government elected to cap the rate that consumers and small businesses would pay at 4.3 cents per kWh. Meanwhile the electricity producers were paid approximately 6 cents per kWh by the province. In essence the province was providing a 600 million dollar per year power-production subsidy to utilities in order to maintain artificially low electricity prices. Policies such as this one clearly provide no incentive for consumers to save electricity or for renewable electricity production. In addition to subsidies, Ontario's electrical resources have "either ignore[d], or greatly undervalue[d], numerous externalities [costs that are not included in the price charged to consumers] accompanying the production and use of energy" (Smil, 2000, p.16). Meanwhile, in order to meet consistently growing demands, the province's energy supply continues to be derived primarily from sources with significant environmental and health impacts. Many concerns surround the traditional energy sources used to generate the majority of the province's electricity, their ability to meet the province's demands, and their overall sustainability (see table 1.1).

The province's electrical energy system was founded using large scale hydroelectric power. While such hydroelectric generation does not contribute toward global warming, it does have significant impacts on the ecological functioning and, in many cases, social framework of the surrounding area. Nuclear power (the province's main source of electricity today) has proven

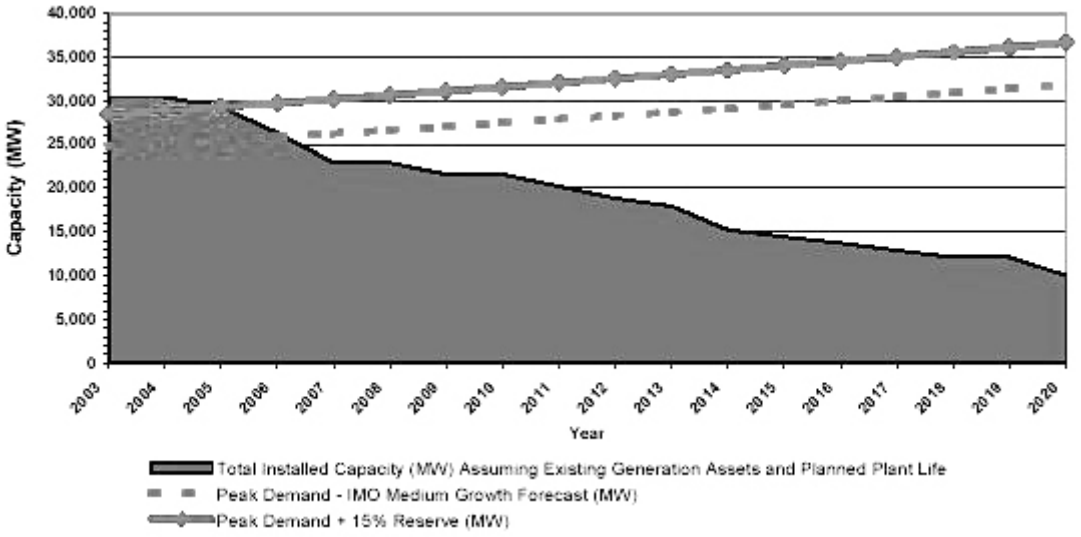
itself to be costly and to have long lasting adverse environmental impacts. However neither hydroelectric nor nuclear are immediately as environmentally disruptive as is the province's reliance on fossil fuels. Traditional fossil fuel generated electricity (i.e. using coal and natural gas) has contributed significantly to air quality impacts and global warming. The Nanticoke coal fired electricity generation station on Lake Erie is Canada's largest single source of air pollution (Ontario Clean Air Alliance, 2004, p.1).

Experts suggest that in Ontario, due to greenhouse gas induced climate change "by the end of the 21st century, temperatures are projected to rise 3-6 degrees Celsius in winter and 4-8 degrees Celsius in summer" (Union of Concerned Scientists and the Ecological Society of America [a], 2003). Impacts may be much more severe at northern latitudes where recent studies have indicated that global warming is occurring at twice the global rate. Such a rise threatens to alter the ecological balance of the province through impacts including, but not limited to, reduced water levels in the Great Lakes and effects on the range of plant and animal species.

In addition to global warming, "air pollution in Ontario is so serious that the Ontario Medical Association has declared it a 'public health crisis'" (David Suzuki Foundation, 2003, p.11) costing the province more than ten billion dollars per year in health care costs. The Canadian Wind Energy Association (2004, p.4) adds that "approximately 1 out of every 13 non-traumatic deaths occurring in Canadian cities can be attributed to air pollution from the burning of fossil fuels". The combined impacts of these traditional sources of electricity generation in Ontario have significantly dimmed hopes of meeting long term sustainability goals.

Despite a historic reliance on supply side policy initiatives, Ontario is faced with serious electricity shortages in the not too distant future. One of the main reasons for this is that "all of the province's existing nuclear generating facilities, which currently account for 28% of the province's generating capacity, will reach the end of their projected operational lifetimes by 2018" (Winfield et. Al, 2004, exec-sum). Even more urgent is the fact that current projections have suggested that "without new supply and substantial conservation efforts, Ontario could have insufficient power to meet its peak requirements by 2006" and have only half of the generation capacity it needs to meet the province's needs by 2014 (ECSTF, 2004, p.1). The severity of Ontario's supply shortages has recently been recognized by Energy Minister Dwight Duncan who stated that "between now and 2020, factoring in the growth of our economy, approximately 25,000 megawatts of our electricity capacity needs to be replaced" (Duncan, 2004) (See figure 2.1). What remains to be seen is what sources of energy will be sought after in Ontario in order to address lingering supply issues and whether or not efficiency and conservation will be sufficiently integrated into future energy policies.

***Figure 2.1 Existing Generation vs. Peak Demand***




Source: (Electricity Conservation & Supply Task Force. 2004, p.1)

## 2.3.2 Ongoing Problems

The past five years have been "a period of extraordinary change and upheaval in Ontario's institutions and policies related to electricity" (Winfield et. Al, 2004, p.1). The OPG review committee (2004, p.2) adds that the electricity sector has "been destabilized by more than a decade of abrupt and often unpredictable policy swings". Such instability, which has typified the electrical system in Ontario of late, is the culmination of the gradual but consistent history of mismanagement and ideological disparities.

Perhaps the greatest flaw in Ontario's system has been its continued reliance on "supply by a narrow and limited number of large generators, instead of efficiency strategies and a diverse generation portfolio" (David Suzuki Foundation, 2004, p.2). Ontario's situation is typical of many developed countries where energy supply systems have been regarded as being "necessarily large to achieve economies of scale and support massive capital investments… [and has encouraged the idea that] energy supply systems required the creation and support of natural monopolies, that duplication was economically inefficient, and that the public interest could be protected only by state-owned and –operated monopolies" (UNDP, 2000, p.425). Such fallacies have maintained the current provincial infrastructure and associated decision making.

Although electricity in the province was traditionally derived from renewable hydropower, today the system is "dominated by large outdated facilities that burn coal – the most polluting fossil fuel – and by aging nuclear plants, which are characterized by unresolved safety issues…, chronic underperformance, and massive cost overruns" (David Suzuki Foundation, 2004, p.1).

The poor performance of the nuclear industry in Ontario has, over much of the past decade, forced OPG to increase the output of its coal power plants by as much as 120% to ensure adequate supply (Ontario Clean Air Alliance, 2004, p.2). It has also, in no small part, contributed to Ontario Hydro's accumulated debt. To add to the supply side problems is the fact that the province has done little to implement energy efficiency and conservation strategies since the programs initiated by the Ministry of the Environment and Ministry of Energy in the early 1990's (which have since been abandoned).

Ontario's electricity sector has lacked the long term planning and foresight it so desperately requires. For over a decade, the province debated the merits of opening the electricity sector to competition and market forces. Meanwhile, in the years since the development of the Darlington Nuclear Facility in 1993 neither Ontario Hydro nor OPG developed any major new generation capacity. Ontario's decision makers rested the future of the electricity sector in the hands of the free market because they believed that market forces would attract new supply once the sector was opened in 2002. However by failing to set the conditions for long term renewable contacts to develop or establishing an appropriate market their vision failed. What transpired should not have come as a surprise. After all, as Hawken et al (2000, p.261) suggest "for all their power and vitality, markets are only tools. They make a good servant but a bad master and a worse religion". The province's linear and one dimensional policy choices cost "valuable planning and construction time from the late 1990s onward" (OPG Review Committee, 2004, p.10). In the mean time, since 1997, "a significant portion of the province's nuclear generating facilities were taken out of service for safety and maintenance overhauls" (Winfield et. al, 2004, exec sum.). Currently, only five of Ontario's eight nuclear units are in operation and four of the units in operation are rapidly reaching the end of their working lives. The poor performance from nuclear reactors in the province has forced increased reliance on coal fired electricity generation. Despite this reality the province still verbally stands by its commitment to close all of the province's coal fired generating stations (responsible for 6420 MW of electricity) by 2007. If such a goal is to be met, if the province is to meet the electricity needs of its population, and if it is to address the sustainability goals of the province, nation and global community, policy changes must be made.

### 2.3.3 Surrounding Politics

Political ideologies have "historically focused mostly on building new capacity rather than aggressively seeking energy efficiencies" (David Suzuki Foundation. 2003 p.9). This has been the case not only in Ontario but throughout much of the world. In addition, Hawken et al (2000, p.273) point out that "all but a handful of states and nations, for example, reward regulated

energy utilities for selling more energy and penalize them for cutting bills". As a result, "institutional and market arrangements [favour] energy consumption rather than conservation" (Stanford, 1997, p.419). Traditional political approaches and market forces have supported unsustainable electricity sources such as coal, nuclear and natural gas. Of these conventional sources, coal - the dirtiest fossil fuel - remains one of the most popular and widely used because its prices are highly subsidized and unreflective of true costs. Coal prices are therefore less volatile than those of oil and natural gas. The previously mentioned conventional energy systems have been promoted by governments through "direct financing, research funds, tax credits, and guarantees to advance and subsidize particular development and production activities, thus favoring one form of energy over others" (Smil, 2000, p.37). For example, Elwell and Dyck (2002, p.8) point out that in Canada, between 1970 and 1999 direct federal spending on fossil fuel based energy was 40.4 billion dollars. Similarly, over the past fifty years, Canada's nuclear industry has received funding of over 16.6 billion dollars.

Government subsidies and funding have created an uneven playing field in the electricity sector by influencing both consumer and producer behaviour. Elwell and Dyck (2002, p.8) theorize that "perverse subsidies are contrary to the principles of sustainability because they reduce costs or distort revenue such that the returns from traditional energy sources are inflated beyond normal economic levels, representing a failure of both economic as well as environmental and social policy". They are therefore among the largest obstacles in the way of implementing sustainable energy strategies. Such subsidies give selected competitors an unfair financial advantage, thus, inhibiting true competition and distorting market signals. The UNDP (2000, p.425) suggests that conventional energy subsidies are "financially unsustainable as well as largely counterproductive…and generally prolong inefficiency and harmful emissions throughout the energy chain". Furthermore, they add that "if subsidies were phased out, and externalities fully reflected in energy prices, market forces could achieve many of the aims of sustainability" (UNDP, 2000, p.423).

### 2.3.4 Current Legislation/Policy in the Province

Recent statements made by Ontario Energy Minister Dwight Duncan and Prime Minister Paul Martin suggest that the need to integrate sustainable decision making into Ontario's electrical policy is beginning to be recognized. One of the first steps in this transition was the acknowledgement by Dwight Duncan that if you "factor in the rising costs of fossil fuel as well as the high cost of new technologies to generate green, renewable energy…it is evident cheap power is a thing of the past" (Anonymous [a], 2004). He added that "we estimate that in order to meet

the looming supply-demand gap, an investment of $25 to $40 billion will likely be required to keep the lights on over the next 15 years" (Duncan, 2004). To validate these statements the provincial government removed the price cap previously implemented and, as of April 1, 2004, introduced a new pricing format that would see customers pay 4.7 cents per kWh for the first 750 kWh consumed and 5.5 cents per kWh for consumption beyond that level (Winfield et. Al, 2004, p.3). In addition the provincial government aims to have 800,000 "smart meters" in place by 2007 that will allow utilities to charge higher rates when demand and prices are high thereby encouraging customers to conserve electricity during peak times. The province's goal is to have all customers equipped with such "smart meters" by 2010 (Spears, 2004 [a]). Such policies retain substantial subsidies and have yet to acknowledge the full range of externalities involved in electricity pricing, yet are at least a step in the right direction.

Another glimmer of hope for Ontario's electricity future was the July 2003 announcement that the provincial government "would introduce a requirement that the amount of electricity provided in Ontario from renewable sources (defined as hydro, wind and biomass) would, starting in 2006, increase by 1% per year over eight years to total 3,000 MW by 2014" (Winfield et. Al, 2004, p.2). This statement was further updated by 2004's provincial goals to decrease electricity use by 5% (a target of 1,350 MW) through efficiency and conservation by 2007 and provide 5% renewable energy by 2007 and 10% by 2010. Specific projects were announced on November 24, 2004 that included plans for 10 new projects that will provide 395 MW of new renewable generation (enough to power 100,000 homes). The government also agreed to purchase power from these projects at a price of approximately 8 cents per kWh for the next 20 years (Brennan, 2004). Although certainly positive in nature, organizations such as the David Suzuki Foundation suggest that "these goals represent modest targets that can be surpassed if clear policies are implemented to diversify, encourage, and support the adoption of renewable energy sources throughout the province" (2004, p.2). In addition, these plans fail to acknowledge the external costs of traditional electricity sources opting instead to commit to long term subsidization of renewable power.

Another positive initiative has been the Ontario Energy Ministers proposal to establish a new independent body called the Ontario Power Authority whose duty would be to ensure long-term supply adequacy in Ontario, forecast resource needs and prepare an integrated system plan for conservation, generation and transmission. The Ministry of Energy would maintain responsibility for setting conservation targets, renewable electricity use goals and the overall supply mix of the province. In addition, as of December 2004 the Ontario Energy Board has made the promotion of energy conservation more attractive for electric utilities by establishing a lost revenue adjustment

or shared savings mechanism allowing utilities to recover and profit from expenditures on conservation and demand side management in 2005.

In June 2004, the Government of Ontario proposed Bill 100 designed to restructure the province's electricity sector in order to "promote the expansion of electricity supply and capacity, including supply and capacity from alternative and renewable energy sources, facilitate load management and electricity demand management, encourage electricity conservation and the efficient use of electricity and regulate prices in parts of the electricity sector" (Ontario Energy Board, 2004). This legislation, which received Royal Assent on December 9, 2004, may for the first time in Ontario embrace values other than adequacy and reliability of supply. Yet there are few direct references in Bill 100 to the "social benefits, the benefits to health and welfare, to economic development, to avoided environmental costs, to improved reliability, and to improved resiliency of an electricity supply system redesigned to take maximum advantage of Ontario's abundant renewable resources" (Gipe, 2004 [b]).

While it seems that many of the problems with Ontario's electrical energy generation sector are beginning to be recognized and measures put in place to address the issues, policy recommendations thus far have not led to concrete and enforceable legislation, they have focussed more on balancing consumer satisfaction and industry demands than on implementing aggressive and truly sustainable policies.

## *2.4 Examples of Existing Canadian Initiatives and Technology.*

Although sustainable energy initiatives thus far in Ontario have lacked the necessary commitment to meet Kyoto targets and ultimately lead to a sustainable future, there have been several incremental, yet nonetheless positive, initiatives in Canadian communities. Such changes began to take shape as far back as the 1970s when rising oil prices as well as "the growing awareness for energy related pollution, and the possibility of climate change … all contributed to a re-evaluation of energy use" (UNDP, 2000, p.13). By the early 1990s government organizations such as the British Columbia Hydro and Power Authority had become "mindful that it's cheaper to conserve electricity than to produce it" (Lush in Field, 1995 p.18). Accordingly, using its "Power smart program" BC was able to persuade 35 percent of "buyers of new electric motors in the province to choose the high-efficiency models, despite their higher cost" by offering rebates based on the efficiency rating of the product (Lush in Field, 1995 p.18). This program was especially meaningful considering that "electric motors are by far the biggest consumers of energy in Canada – every factory, office and residential building relies on them" (Lush in Field, 1995 p.18). BC's Power Smart Project exemplified how investments and

financial incentives to promote energy efficiency can be extremely cost effective and contribute to long term sustainability.

More recent examples include Calgary's the "Ride the Wind" initiative under which the city's light rail system is powered by wind-generated electricity. In St. John's municipal building retrofits are expected to deliver significant energy savings, improve workplace lighting and comfort levels as well as reduce maintenance costs. In Ontario OPG has installed one of North America's largest wind turbines at the Pickering Wind Generating Station. The 1.8MW turbine, installed in 2001, generates enough electricity to meet the needs of 600 homes. In addition, the Huron Wind project, Ontario's first commercial wind farm was created in 2002 and provides enough electricity on an annual basis to power 3,000 homes in Ontario (Huron Wind, 2002). With green energy now available in limited quantities niche markets have begun to emerge. Green power suppliers such as "selectwind" and the Grey-Bruce renewable energy co-op sell wind energy in various quantities ("tags") for between 7.5 and 9.1 cents per kWh. In addition to these regional examples the federal government launched its home efficiency grant program on October 15, 2003, enabling home owners to have energy audits conducted and receive information and possibly grants to improve the energy efficiency of their homes. Initiatives such as these clearly show what is possible and indeed what is lacking from an overall energy policy for the province and nation.

# 3.0 Sustainable Options – Supply

While even the most pessimistic analysts agree that the world's conventional energy supplies are likely to last for at least the next half century, such a system is completely unsustainable for a variety of environmental, economic, and social equity reasons. The UNDP (2000, p.2) points out several of the unsustainable aspects of the current system including the fact that "modern fuels and electricity are not universally accessible, that the current energy system is not sufficiently reliable or affordable to support widespread economic growth… [and] negative local, regional, and global environmental impacts of energy production and use threaten the health and well-being of current and future generations". A sustainable electricity system must both supply "adequate energy services for satisfying basic human needs, improving social welfare, and achieving economic development—in short, energy as a source of prosperity" and not "endanger the quality of life of current and future generations and should not exceed the carrying capacity of ecosystems" (UNDP, 2000, p.31). For Ontario, and indeed the global community, to have a sustainable electricity future, the guiding principles of 1987's Brundtland Report must be embraced. Ontario must aim for development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p.8).

A sustainable electricity future for Ontario will be dependent upon both demand and supply side initiatives requiring reduced use as well as increased production from renewable sources. Reddy and Painuly (2004, p.1431) suggest that "the essential characteristic of a sustainable energy system is its ability to deliver required services without exhausting resources" and that "the first step to create such a system is to use the existing resources efficiently and increase the use of resources that are renewable". Yet while demand side management is likely the most cost effective and initially valuable initiative, it does not address the problems associated with electricity from traditional sources. While it is true that "no primary energy source and its associated technology are completely free of environmental and other drawbacks" (Chow et al, 2003, p.1530), renewable options exist that can provide electricity with significantly fewer adverse impacts than conventional sources.

Electricity supply is labelled "renewable" or "green" when it is generated from natural, self-sustaining sources that cannot be depleted and are environmentally benign. As The Clean Air Partnership (2003, p.6) states "these sources can generally be replaced, will always be available, can be sustained indefinitely, and are essentially non-polluting". Traditional sources of renewable energy include small scale hydropower, wind, solar, biomass, geothermal and energy generated from waste (see table 3.2). Although at present less than one percent of Ontario's

electrical energy demands are met from such sources there is significant potential to increase the supply of electricity from renewable sources. For example the Clean Air Renewable Energy Coalition ([b], 2004, p.6) suggests that Canada's "renewable energy sources could be equivalent to today's production of nuclear and thermal power combined". The Canadian Institute for Environmental Law and Policy (2002, p.2) adds that "the approximately 40,000 Gigawatt hours (GWH) per year of power generated from the 7,519MW of coal fired stations in this province could be eliminated through a combination of energy efficiency measures and new sources of renewable, low environmental impact electric generation". Overall, the province of Ontario has not yet begun to realize the potential for electric energy generation from its renewable sources.

## *3.1 Benefits from the Shift to Renewable Sources*

Shifting Ontario's electric energy supply system to renewable sources has a number of benefits. Of course the reason for this is that "every megawatt-hour of green power that is contracted results in …one less megawatt-hour of energy generated from conventional sources" (The Clean Air Partnership. 2003, p.13). Silverman & Worthman (1995, p.14) point out that much of their potential "lies in the fact that renewables are essentially limitless in supply…; they are largely non polluting and otherwise inoffensive to the environment…; they are versatile in application size, location and customer; require no importation and (excepting biomass) have no fuel costs".

In addition to their obvious environmental and health benefits, renewable electricity generation offers a number of social and political advantages. For example the UNDP points out that "renewable resources are more evenly distributed than fossil and nuclear resources, and energy flows from renewable resources are more than three orders of magnitude higher than current global energy use" (UNDP, 2000, p.12). By providing the potential for wider and more universal access to electricity, renewable sources may contribute to social equity. In addition to being potentially more equitable, renewable sources also may offer enhanced security of energy supply. This is because many forms of renewable energy, or at least a diverse portfolio of renewable sources, offer "availability of energy at all times in various forms, in sufficient quantities, and at affordable prices" (UNDP, 2000, p.11). Several "green" electricity options including wind plants can be built quickly, often in less than a year (once approvals are in place), which, as the David Suzuki Foundation (2004, p.6) highlights, "enables developers to respond more accurately to electricity use projections and short-term changes in demand". Such sources are thus much more adaptable and in line with predominant global political frameworks.

Another benefit of many renewable electricity sources is that they are able to produce significantly higher levels of employment than similar investments in traditional electricity supply. The Canadian Wind Energy Association (2004, p.4) states that "for every million dollars invested, an average of 36.3 jobs are created in the energy efficiency sector or 12.2 in the renewable energy sector. For every million dollars invested in conventional energy, an average of only 7.3 jobs are created". The higher employment levels are attributed to "the relative labour intensity of the work and the jobs created from the re-spending of energy savings" (Canadian Wind Energy Association. 2004, p.4). In addition to creating more jobs, "government investment in energy efficiency and renewable energy can leverage significant private investment. On average, every million dollars of government spending was found to result in six million dollars of private-sector spending" (Canadian Wind Energy Association. 2004, p.4). By creating employment opportunities and stimulating the economy renewable electricity policies can lead to significant community economic development. Despite the multiple benefits of renewable sources, they alone are insufficient to ensure sustainability and must be supplemented with additional considerations.

## *3.2 Renewable Electricity Status Check*

### 3.2.1 Renewable Electricity in Ontario

A comprehensive list of renewable electricity sources would include small scale hydropower, wind, solar, biomass, geothermal and energy generated from waste. However, while these sources do offer potential they are, for a variety of reasons including high costs, not all practical in Ontario at the present time. The Canadian Institute for Environmental Law and Policy (2002, p.2) suggests that at present "there are three major sources of available renewable energy for electricity generation in Ontario" (See table 3.1).

***Table 3.1: Potential for Renewable Electricity Sources in Ontario***

| RENEWABLE ENERGY SOURCE | MINIMUM POTENTIAL IN (MW) |
|---|---|
| Wind | 6,390 |
| Hydro | 953 |
| Biogas | 71 |
| Total | 7414 |

Source: The Canadian Institute for Environmental Law and Policy, 2002

Of the three options mentioned above it is likely that wind generated electricity has the most promising future in Ontario. Yet while "wind is the fastest growing energy source in the world," the David Suzuki Foundation notes that "Ontario is lagging behind" (2004, p.6). Even the figure of 6,390 MW (over 20% of Ontario's total demand) of installed wind generation capacity is likely an understatement of the real potential for Ontario. The main reason for this is that turbines are now larger, more powerful and more efficient than ever. Furthermore the price of wind generated electricity has, over the past several years, steadily and continuously decreased. Based on the experiences of countries like Denmark, Spain and most notably Germany, some have suggested that Ontario could install as much as 8,000 MW of wind-generating capacity by 2012 (David Suzuki Foundation, 2004).

Ontario's electricity empire was established through the use of hydroelectricity. There is little potential remaining for such large scale projects that have a host of associated environmental and social concerns. Nevertheless today's "green" hydro projects can be implemented using small scale (less than 30MW), run of the river designs that can mitigate the impact of electricity generation (Canadian Institute for Environmental Law and Policy. 2002, p.13). The Ministry of Natural Resources (2005) conservatively estimates that there is 2,000MW of additional waterpower potential in Ontario. Such projects are vital to Ontario's electricity system because, as originally envisioned, they are able to supply a cheap and more importantly constant supply of electricity to the grid.

A third source of renewable electricity within the Province is biogas. Biogas is a "conglomeration of different gas sources that have organic origins" (Canadian Institute for Environmental Law and Policy. 2002, p.14). Its electricity generation potential is revealed when the gases (produced from the decomposition of organic matter) are captured and burned rather than being allowed to escape into the atmosphere. While biogas has a very limited potential for electricity generation in Ontario, it is worthy of consideration as it uses methane, a greenhouse gas 26 times more potent than carbon dioxide, and prevents it from directly contributing to global warming.

Although solar electricity generation remains largely cost prohibitive in most parts of Ontario "high growth rates are leading to a general continuing downward trend in grid connected PV system prices" (David Suzuki Foundation, 2004, p.7). Currently in Ontario solar energy is used primarily for hot water heating (an efficiency initiative) and not electricity generation. However the long term potential of solar electricity is tremendous. For example "the province could install 1,263 MW of PV systems; 800,000 solar domestic hot water systems; 120,000 solar pool heaters; solar passive design in 420,000 new homes; 2,000,000 m2 of commercial and institutional solar

hot water systems; and 825,000 m2 solar air ventilation systems" (David Suzuki Foundation, 2004, p.7). The combination of such systems "has the technically feasible potential of supplying by 2025 the equivalent power that coal provided in 1999, or about half the electricity generated by all of Ontario's nuclear power plants" (David Suzuki Foundation, 2004, p.7).

### 3.2.2 Renewable Electricity in the Global Community

The current status of renewable electricity in the global community is nowhere near its potential. However, analysts predict that while "presently, renewable energy represents 5% of all prime energy use…by the year 2060, it is strongly predicted that it will reach 70%" (Sayigh, 1999, p.29). The European Union has expressed that it hopes to meet 22 percent of its electricity needs from renewable sources by 2010 (Canadian Wind Energy Association, 2004 p.1). For over a decade the world's fastest growing energy technologies have been wind power and photovoltaics. Yet such resources have significant and very real limits to their wide scale use. Wind generated electricity is widely distributed but erratic. Solar energy has almost limitless potential yet is constrained by "the availability of efficient and low-cost technologies to convert solar energy into electricity and eventually hydrogen" (UNDP, 2000, p.163). Furthermore both of these resources are only available intermittently (i.e. when the sun shines and the wind blows) and can therefore not provide a stable base-load electricity supply unless linked to a storage mechanism. However these forms of renewable energy can be used effectively to manage electricity peaks (David Suzuki Foundation, 2004, p.7). Overall it seems that with global investments in the energy supply infrastructure over the next 30 years projected to be 16 trillion dollars, there is a tremendous opportunity to "orient a large and increasing share of these investments towards renewable energy, in order to advance the transition to a global energy system for sustainable development" (Renewables 2004. 2004, p.33).

## *3.3 Case Study: Toronto's Windshare Project*

While renewable electricity's potential is still largely unrealized, several positive initiatives have been made towards a "greener" electricity future around the globe. One such project can be found in Toronto, Ontario where North America's first urban wind turbine began generating electricity in January of 2003. The 91 metre turbine was built at the west end of Exhibition Place and is the first of two jointly planned efforts between the WindShare Co-op and Toronto Hydro. The turbine is capable of producing 1,400 MW hours of energy per year (enough to power approximately 250 homes). A second similar turbine is currently being developed at Ash bridges Bay in Toronto's east end. Perhaps more important than the commodity produced from this

project is its precedent setting nature as the first community driven wind power co-op in North America. The very recognizable symbol of clean electric generation in such a high profile area serves to raise awareness of renewable sources of electricity and their potential roles in the provinces future.

The project has its roots in a community based environmental organization called the North Toronto Green Community. In 1998 this group formed the Toronto Renewable Energy Co-operative (TREC) and began to develop a proposal for a community owned wind turbine. Based on strong initial public interest, in 1999 the TREC formed WindShare an aligned themselves with Toronto Hydro Energy Services to put their proposal into action. The project was initially started "to provide an opportunity for citizens to generate Green Power in Ontario's new deregulated electricity marketplace" (Toronto Renewable Energy Co-operative, 2004, p.1). As such, half of the project's bill (1.8 million dollars) was paid for by Toronto Hydro and the rest by 421 community members who purchased shares in the co-op in $500 increments. This initial investment is rewarded as co-op members receive a dividend based on the electricity sold by WindShare. While the first three years of the project will see the co-op sell electricity to the local retailer, it is the ultimate goal of WindShare to allow its members to use the electricity more directly (through net billing).

The TREC has a "three-fold mission to advocate for progressive renewable energy policy; conduct public outreach on the benefits of renewable energy, community based green power solutions, and the costs of smog and climate change; and engage in Project development and provide technical assistance for real, on the ground community-focused green power projects (Toronto Renewable Energy Co-operative, 2004, p.2). This exemplary organization is well on its way to achieving such goals. The successful implementation of the Exhibition Place turbine is estimated to displace "up to 1,800 tonnes of carbon dioxide (CO2), 8,400 kilograms of sulphur dioxide ($SO_2$) and 5,600 kilograms of nitrous oxide ($NO_x$) - the main ingredients in acid rain, smog and ground-level ozone" (Canadian Cooperative Association, 2004, p.1). In addition WindShare has been named the Canadian Wind Industry's 2004 Organization of the Year. While revolutionary in North America, it is important to note that renewable energy co-ops have been much more widely used and accepted in counties such as Denmark where 100,000 co-op members have been directly responsible for 80% of the wind generated electricity (Toronto Renewable Energy Co-operative, 2004, p.2). The success of the TREC has shown that such programs have the potential to be equally successful in Ontario.

## *3.4 Case Study: German Wind Power*

While the Danes certainly have a number of admirable policies and achievements in renewable energy, the country that has led the way in recent years is Germany. The Germans have been able to add 16,000 MW of generating capacity in the past 12 years due to supportive renewable energy legislation and fiscal incentives (Scheer, 2004). While Ontario politicians pat themselves on their backs for their proposed 300MW of new renewable electricity generation to the Ontario grid the Germans were able to add 3000 MW of new wind and solar generation to the countries electricity grid in 2003 alone (Scheer, 2004). Other achievements include the addition of 100,000 solar systems to rooftops and the employment of "nearly 120,000 people across Germany who build, install and operate solar, wind and biomass plants" (Scheer, 2004). In addition there are now over 15,000 windmills in Germany and "3000 homes meet all their energy needs with solar or other forms of renewable energy" (Scheer, 2004). The German commitment to renewable electricity becomes entirely clear when one considers that even the Reichstag, the home of the German parliament in Berlin, meets 85 percent of its energy needs from renewable sources (Scheer, 2004).

Germany's success lies not only in its capacity created, but in its visionary legislation that set the rules to allow renewable energy technologies to flourish. Germany's 1991 Electricity Feed Law and associated Windpower Development Programme has been a tremendous success. The "law provides firm prices for an extended period of time to warrant the financial risk of investment – and to ensure market adoption of a variety of renewable options" (David Suzuki Foundation, 2004, p.8). These are, as Scheer (2004) points out, similar to the fixed prices and long term contracts that are offered to Ontario's nuclear generators. Scheer adds that if Ontario had followed a path similar to Germany's it could be producing 17 per cent of its electricity with new renewable sources of energy today (Scheer, 2004). By offering such market incentives to renewable sources Germany has been able to remove the pervasive market uncertainty and guarantee the ability of renewable generators to actually connect to the grid. Another reason why the Germans have been so successful in their efforts is that they have not relied on one approach alone such as simply opening the market to competition or relying on fiscal incentives. Instead they have implemented a variety of programs ranging from "the promotion of research, development and demonstration to the improvement of market conditions, of regulatory, administrative and institutional framework conditions, and of information, education and international cooperation" (Gutermuth, 1998, p.68). The result of this approach has been sustained optimism in the renewable electricity industry, allowing the benefits of renewables to be realized.

The German government has been able to use financial incentives both directly and indirectly to stimulate new sources of renewable generation. Wille (2004, p.42) highlights that "politically backed market incentives, for instance, have turned wind power into an important source of electricity within just a decade". Direct financial incentives have included measures such as capital subsidies (investment assistance in the forms of grants, allowances and operational cost grants), preferential loans and tax relief. For example, between 1990 and 1993 Germany's Federal Ministry for Education, Science, Research and Technology began providing combined federal and state investment grants to foster the development of the nation's photovoltaic roof program. This successful program led to the installation of over 2000 units and paved the way for future programs. Since 1994 the Ministry of Economics has provided investment grants approaching U.S. $100 million and leading to over 15,000 installations of various renewable energy measures (Gutermuth, 1998). In addition, since 1990, "the Deutsche Ausgleichsbank, which is wholly owned by the federal government, has granted low-interest loans to small and midsize companies for installations using renewable energy" (Gutermuth, 1998, p.75).

While such direct subsidies certainly have played a tremendous role in the countries renewable electricity plans, Wille (2004, p.45) reflects that "it was not state subsidies that led to the unparalleled expansion of renewables". Germany's 1991 Electricity Feed Law introduced a legal obligation "requiring utilities across the country to pay 90% of their annual average retail rate for purchases from clean energy sources such as wind turbines" (David Suzuki Foundation, 2004, p.8). Essentially the Electricity Feed Law "obliges electricity companies…to buy the electricity produced from [renewable sources] and it sets the buy-back rates" (Gutermuth, 1998, p.70). The utilities pay a price premium for the green electricity which is then passed on to all electricity consumers within the region. Such guarantees have "made the operation of wind-powered plants profitable, and the banks have been willing to grant loans to build the plants on the strength of the statutory guarantee to purchase the power" (Wille, 2004, 45).

With successful renewable electricity policies already in place, and a flourishing renewable electricity market the German government continued to raise the bar when in July 2004 it introduced a new Renewables Act. This new legislation is "intended to increase the total contribution of renewable energy to Germany's electricity supply, from 5% to at least 12.5% by 2010 and at least 20% by the year 2020" (David Suzuki Foundation, 2004, p.8). It integrates more sophisticated premium pricing schemes aimed at stimulating renewable electricity projects even in less than ideal sites. For example the updated Act offers "higher premiums for less windy sites to encourage development in low wind areas of central Germany" (David Suzuki Foundation, 2004, p.8). The new legislation, which is revisited and updated twice annually to

ensure the desired objectives are being met, also aims to reduce land use conflicts and effectively integrate wind turbines into the overall electricity network. The 2004 legislation clearly illustrates how any associated costs for grid connection and network distribution are to be calculated and allocated to both the system owners and the grid operator. The law also increases the transparency of how these costs are determined (David Suzuki Foundation, 2004, p.8). Overall, Germany's renewable electricity policies have served to "diversify the use of a variety of renewable energy technologies, and achieve sustained market transformations" (David Suzuki Foundation, 2004, p.8).

While Ontario lags behind and spins its wheels while trying to commit to a sustainable and realistic electricity future, the German government seems to prefer the spinning of wind turbines. The country is well on its way to meeting and even surpassing its Kyoto targets (Wille, 2004, p.43). The German vision of its electricity future involves the replacement of a small number of centralized generating facilities, similar to those in Ontario, with many, even thousands, of decentralized facilities (Scheer, 2004). Scheer (2004) adds that a main benefit of such distributed generators is that they "require fewer high-voltage transmission lines than the centralized plants, decreasing the need for construction of major new transportation corridors". Such a system is more resilient, less brittle and offers numerous other sustainability benefits including increased opportunities for local participation and employment. It is the German government's goal to reduce its carbon dioxide emission levels by 25% below 1990 by 2005 (recall that Canada is struggling to lower its $CO_2$ emissions by 6% by 2010). Moreover the country aims to meet half of its primary energy consumption from renewables by 2050 (Wille, 2004, 59). The David Suzuki Foundation (2004, p.8) points out that "no other renewable support mechanism in the world has produced more renewable energy than the German Renewable Energy Mechanisms". The visionary policies and ambitious goals of the German government and people can and should serve as a model for other nations and jurisdictions around the world.

# 4.0 Sustainable Options – Demand

## *4.1 Efficiency Overview*

Supply side initiatives and the generation of new "renewable" electricity are ultimately necessary; however, as the UNDP suggests, "the amount of additional energy required to provide the energy services needed in the future will depend on the efficiencies with which the energy is produced, delivered, and used" (2000, p.5). In terms of electrical efficiency, it generally refers to "the ratio of usable energy output to energy input" (Hoffert et al. 2002, p.982) but may be extended to include less energy intensive means of serving the intended purpose such as designing buildings to use light more efficiently or matching the quality of energy sources to their end uses. As such there are many ways efficiency gains can be obtained throughout the various stages of electricity generation, end use and marketing. While energy efficiency has proven itself to be a valuable and cost effective way of reducing electricity requirements, "a lack of good information and advice on energy saving, along with the capital to finance energy efficiency improvements, means that the huge potential for reducing energy demand is not being realized" (Stanford, 1997, p.418). Yet a sustainable energy future, especially in Ontario where future supply is questionable at best and where per capita use is amongst the highest in the world, will be dependent upon reducing the demand for electricity.

There is tremendous theoretical potential for energy efficiency. For example the UNDP (2000, p.428) suggests that "more than 60 percent of the primary energy initially recovered or gathered is lost or wasted in the various stages of conversion and use [and that] [m]ore than 60 percent of this loss or waste occurs at the end-use stage". While 60 percent reductions seem a lofty goal indeed, in Ontario, it is thought by some that by making the transition to more energy-efficient technologies the province could "cut total demand for electric power by 20 per cent between now and 2010, and achieve further reductions after that" (David Suzuki Foundation, 2003, p.1). Such a solution may not only be possible, but may also be the most cost effective. While "the average cost of reducing demand by one kilowatt-hour (kWh) is about 4.5 cents; to produce a kWh in Ontario costs more than 6 cents" (David Suzuki Foundation, 2003, p.3). In addition, as evidenced by the conservation efforts of the 1970's, while "alternative energy sources take a long time to build…energy conservation works relatively quickly" (Dyer, 2004). Clearly the potential for the significantly more efficient use of electricity is high and could lead to numerous benefits in Ontario.

One of the main benefits of energy efficiency initiatives is that they tend to pay for themselves over time. In addition they avoid the associated capital costs of new construction as well as any associated damaging environmental impacts, financial or political risks and are generally more reliable than new power generation (Winfield et al. 2004, Lovins, 1977). Electricity conservation can, much like the development of new power sources, create jobs in development, manufacturing and installation (Canadian Institute for Environmental Law and Policy. 2002). A further benefit offered by Scott et al. (2001, p.123) is that "'security of (energy) supply' can also increase, because fewer energy resources need to be imported or domestic resources will be able to meet demand for a longer period". A more efficient electricity sector is also less vulnerable to failure, system collapse, terrorist attack and may be more easily repaired. Improving energy efficiency also has social justice implications as "poorer people tend to spend a greater share of their income on fuel and electricity" (Scott et al, 2001, p.123). Overall, if Ontario is to prepare for its immediate supply uncertainties and work towards a sustainable future, it must, as the David Suzuki Foundation suggests, become "proficient at obtaining more energy services from lower electricity supply" (2004, p.7).

### 4.1.1 Obstacles to Efficiency

Despite the numerous benefits of energy efficiency and conservation there are, "in practice, many obstacles and market imperfections [that] prevent profitable energy efficiency from being fully realized" (UNDP, 2000, p.200). The most obvious of these obstacles is the fact that current electricity production policies and guidelines "reward generators and distributors for supplying as much electricity as they can, not for providing the energy needed" (Canadian Institute for Environmental Law and Policy. 2002, p.8). This is, of course because electricity utilities are not compensated for, nor do they have any reason to encourage anything but wasteful and maximal use of electricity. Additional obstacles to end use efficiency include a lack of access to technical education and training, the unavailability of capital, perverse investment patterns (especially in Ontario where funding has favoured new power generation over efficiency), and the fact that efficiency initiatives tend to be politically invisible and therefore unpopular. There are also several market imperfections, including "the external costs of energy use as well as subsidies, traditional legislation and rules, and traditions, motivations, and decision making in households, companies, and administrations" that keep electricity efficiencies potential from being revealed (UNDP, 2000, p.200). For example, "if an energy saving measure requires longer than four years to pay itself back in the savings then close to 90% of consumers will opt not to pursue it"

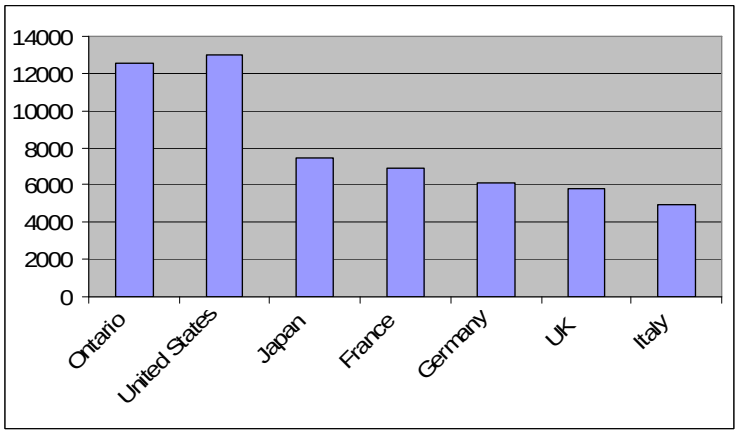
(Canadian Institute for Environmental Law and Policy. 2002, p.10). Despite these obstacles there is tremendous potential for efficiency initiatives in Ontario.

Ontario has, in the past, devoted significant resources to energy efficiency campaigns. In 1989 the Province, acknowledging that it was cheaper to save electricity than to produce it, launched its first official demand side management program. The first three years of existence this program "reduced customer load by 1,000 megawatts [and] had thirty programs available to residential, commercial and industrial consumers, offering and array of information, energy audits, and financial incentives aimed at lowering the cost and risk of efficiency improvements" (Swift & Stewart, 2004, p.69). In 1991 Ontario Hydro was investing $179 million in conservation and energy efficiency programs which by 1992 had achieved cumulative savings to customer bills of over $260 million (Swift & Stewart, 2004, p.87). Swift & Stewart (2004,p.88) add that at this point all signs suggested that efficiency could contribute more energy savings than new nuclear or coal plants would produce and "there was no sign that the energy-efficiency push was running out of steam". Despite such potential and the success of the program, spending on efficiency was slashed in 1994 to less than half of what it was in 1991. It seems that helping customers use less turned out to be less profitable for utilities than had been hoped. In addition, as Swift and Stewart explain, there existed a mindset that "when the economy boomed, there was little interest in conservation or efficiency because energy was too important to become a bottleneck holding back industrial growth; new power plants were commissioned to ensure that demand could be met. During a recession, on the other hand, you could not afford to try to cut back consumption further because you needed the revenue from the sale of electricity to cover the capital costs incurred in building new plants during the boom" (2004, p.90). It seems that if the benefits of efficiency are to be revealed in Ontario the current regulatory obstacles, financial disincentives and many of the prevailing archaic mindsets must first be removed.

## *4.2 Potential to Improve*

Ontario's current levels of per capita electricity use are among the highest in the world. Winfield et al (2004, p.11) note that "while Ontario's levels of consumption of electricity are typical for North America…they are very high relative to advanced economies outside North America" (see figure 4.1).

***Figure 4.1 - Net Electricity Consumption per Capita (kWh), 2000***




Source: (Winfield et al. 2004, p.11).

Clearly Ontario has tremendous potential to promote conservation and become more efficient. Although estimates vary, the estimated overall efficiency for most global energy systems is between 15 and 30 percent (UNDP, 2000, p.32). To improve this gloomy statistic there are a number of contributing energy system components that must be considered including "individual process efficiencies, the structure of energy supply and conversion, and energy end-use patterns" (UNDP, 2000, p.32). A more energy efficient future for Ontario and the global community will require compounding the potential for efficiencies throughout the entire electricity supply process and to be truly sustainable would "need to be at least three times as energy-efficient as today's industrial economies typically are" (Brown et al., 1991 p.37).

Winfield et al (2004) present three technological and behavioural changes that can contribute to a more efficient electricity future. Beginning with the adoption of the most energy efficient technologies instead of conventional products in all sectors, the authors suggest that efficiency and conservation may be achieved as "users would take advantage of financial incentives that reduce the capital cost of energy efficient or non-electric technologies, and innovative financing that would allow them to make purchasing decisions more on a life-cycle cost rather than a first cost basis" (Winfield et al. 2004, Exec. sum). Such financial incentives are almost certainly necessary as "people are not very good at identifying the downstream benefit" of efficiency initiatives (Mills, 2004). Mills goes on to suggest that "the way around this dilemma…may be to give consumers the cash to buy efficient devices up front, with the condition that 'if this gadget translates into X-dollars savings on your monthly bill, you pay me back from the savings'" (Mills, 2004). Such government funded campaigns may be, in the long run, quite cost effective. For example investing in insulation for homes can have the same energy effect as subsidizing heating costs. However, proactive efficiency initiatives have the added, and ultimately more

sustainable, benefits of reducing the needs for new generation projects, reducing greenhouse gas emissions, enhancing local employment effects and improving housing comfort levels.

Winfield et al's second suggestion involves implementing cogeneration in the industrial and commercial sectors. Such measures have tremendous potential to increase the efficiency of generation facilities that, in North America, turn fuel into an average of 34 percent electricity and 66 percent waste heat (Hawken et al, 2000, p.246). Cogeneration facilities would be able to recover the unused heat energy and turn it into a useful commodity. For example in Denmark approximately 40 percent of the nation's electricity is generated from cogeneration plants enabling the conversion of 61 percent of its fuel into a useable product (Hawken, et al, 2000, p.247).

The final suggestion by Winfield et al involves a shift from the use of electricity to natural gas for space heating purposes. Natural gas has proven itself to be less costly than electricity for space heating applications. Recognizing this, many Canadians have responded to pricing signals by converting to natural gas. Such actions clearly illustrate the role that pricing, especially that which includes traditional externalities associated with electricity generation, plays in consumer choices. The UNDP (2000, p.36) adds that "high energy prices also stimulate exploration and development of additional resources, foster innovation, and encourage efficiency improvements" (UNDP, 2000, p.36). Parker et al (2003, p.175) add that the combination of "higher fuel prices triggered by scarcity of supply or higher demand, the introduction of a carbon tax to internalize the costs of environmental and health damage or new public priorities and policies to slow the pace of climate change could stimulate a greater willingness to improve energy efficiency". The potential for electrical efficiency and its associated benefits in Ontario is great. Realizing such benefits will depend upon the province's ability to utilize a variety of policy adjustments and market incentives.

## *4.3 Case Study: California's 2001 Electricity Crisis*

The state of California has a long history of pursuing energy conservation and renewable power production. During the early 1980's such efforts began to be collectively labelled as "demand-side management". Throughout this era "utilities refined the use of practical measures such as incentives, training, low-interest loans and rebates, and reported significant reductions in the demand for electricity among those who took advantage of the programs" (David Suzuki Foundation, 2003, p.16). State allocated funding for energy efficiency measures grew from approximately $200 million in 1980 to a peak of nearly $600 million in 1984 (David Suzuki Foundation, 2003). The 1990's however brought whisperings of a competitive electricity market

and with these rumours came the slashing of efficiency and conservation budgets. In response to the reduced public utility spending the Californian government established a Public Goods Charge fund that came into effect in 1996 under Assembly Bill 1890. The PGC fund imposes a surcharge on all electricity and natural gas consumption within the state resulting in approximately $300 million dollars that can be allocated towards energy efficiency programs including "permanent programs and staff, codes and standards development, marketing programs, and research and development in energy efficiency" (David Suzuki Foundation, 2003, p.17). Despite a rather turbulent history of supply shortages and corporate scandals, California has managed to stabilize per-capita electricity use since 1975 by exemplifying the principles of integrated resource planning including fiscal incentives, higher standards, public education programs, green marketing and research and development.

While the blackout of August 2003 came as a complete surprise to residents of Ontario, the state of California has, since 2000, had to go without the lights on several occasions. Blackouts in California occurred due to a variety of factors; however, many of the large-scale problems seemed to emerge shortly after the Californian utilities began to deregulate in 1999. For example in the summer of 2000, and again in 2001, rolling blackouts affected hundreds of thousands of Californians. Yet as blackouts loomed once again in the summer of 2001, the state was able to respond successfully through a series of demand-side management approaches leading to "a direct reduction in peak-hour electricity consumption ranging from 3,200 to 5,600 MW over the four summer months of 2001" (David Suzuki Foundation, 2003, p.13). In doing so, the state was able to avert what could have been a much larger crisis and clearly show the potential of efficiency initiatives for reducing power demands and saving money.

One of the most immediately successful programs implemented in 2001 was known as the 20/20 rebate program. This innovative incentive program aimed to achieve customer load reductions by offering "a 20 per cent discount on power bills for customers of private utilities who reduced their summer electricity use by 20 per cent compared to the same month in the previous year" (David Suzuki Foundation, 2003, p.13). This program was largely successful due to the fact that it not only targeted peak production in the state, but also aimed to raise public awareness.

Building on the success of the 20/20 program and the avoided blackouts the state continued to expand its energy efficiency programs. In addition to its state funded Public Goods Charge that provides for investment in energy efficiency, the state promoted the accelerated adoption of standards designed to remove low-efficiency products from the market; the integration of energy efficiency into the utilities' electric-resource portfolios; and, new revenue mechanisms to

determine the utilities' fixed cost recovery, ensuring that utilities cannot profit by encouraging increases in electricity consumption nor are they discouraged from energy saving investments (David Suzuki Foundation, 2003, p.14). The state also reinstated its "Integrated Resource Planning" policies. The David Suzuki Foundation (2003, p.15) highlights several of the key components of these policies including the consideration of energy efficiency as an alternative to building new power plants; the consideration of environmental costs of all electricity options; an open, transparent public process with intervenor funding for public interest groups; analysis of the uncertainties and risks posed by different resource portfolios and by external factors; diverse ownership of resources by utilities, independent power producers and customers; and, resource selection that resides on a diverse set of criteria including economic development, environmental quality, fuel and technology diversity, risk mitigation, and electricity rates.

In October of 2002, with the signing of California Senate Bill 1078, California implemented renewable energy portfolio standards for utilities. The Bill called for a minimum of 20 percent renewable energy generation by the year 2017 (Swift & Stewart, 2004, p.113). In June of 2003 however this agenda was accelerated to the year 2010 with the approval of California's Energy Action Plan. To accomplish this goal the state utilities aim to build 600 MW of renewable capacity per year over the next six years.

Overall, California's investments in energy efficiency, since about the mid-1970's, have provided enough energy savings to defer the construction of 20 large power plants (David Suzuki Foundation, 2003). Such achievements have been possible, in large part, due to the state's ongoing commitment to "develop public education and policy initiatives that raised awareness and fostered an infrastructure of contractors, energy service companies, vendors and retailers" (David Suzuki Foundation, 2003, p.13). The state has been able to cut its overall usage by approximately 3,600 MW by supporting efficiency measures and aggressively pursuing conservation. To put things in perspective "that's the same amount Ontario is spending to restart a Pickering reactor that will produce 515 megawatts" (Blackout, 2004). More impressive has been the fact that California has "reduced peak power demand by 20%, or 10,000 MW over the past 20 years, with a combination of utility demand-side management programs, and building and appliance standards" (Winfield et al. 2004, Exec. sum).

While its past was filled with blackouts and questionable supply, California's electricity future looks bright. The state's electricity system and the policies that surround it continue to evolve. The programs and incentive structures that have been implemented have created a positive feedback loop of sorts. For example, as efficiency programs stimulate the market for more efficient products, minimum standards can be raised. As it looks towards the future, the

state continues to rely on the following key features "a solid foundation of policies, agencies, programs, staff and contractors that can leverage increasing energy savings as funding is increased; an integrated strategy of incentive programs, efficiency standards and research and development that drives the increasing availability of energy efficiency technologies; [and,] significant funding for public awareness, education and outreach strategies as well as industry training" (David Suzuki Foundation, 2003, pp. 20-21). Overall California's triumphs, in the face of hardships, provide an excellent example of how to react to immediate supply shortages as well as future needs.

## *4.4 Case Study: Waterloo's Residential Energy Efficiency Project*

Recognizing that "the residential sector is an important area for improvement, as it accounts for 22 percent of global energy consumption", beginning in early 1990's the Canadian federal government launched a series of energy efficiency campaigns (Parker et al, 2003, p.169). One initiative, piloted by Natural Resources Canada in 1997, was the national EnerGuide for Houses (EGH) program. This program intended to reduce Canada's greenhouse gas emissions by encouraging residents to improve the energy efficiency of their homes through a variety of means including retrofits and purchasing energy efficient products. In addition, the project aimed to foster the development of energy efficiency expertise in the residential sector and educate homeowners so that they may make wise and responsible choices in their homes (Green Communities, 2004). Such programs, which were implemented across Canada, were intended to address the fact that "despite substantial improvements in efficiency in newer houses…total Canadian residential CO2 emissions [were] increase[ing] gradually in the late 1980s and 1990s" (Parker et al, 2003, p.172). These residential retrofit programs were designed to address both space and hot water heating inefficiencies (generally fuelled by natural gas) as well as the inefficient use of electrical appliances, lighting space cooling as well as some water heating. One such program, sponsored in part by the EGH, is the Residential Energy Efficiency Program (REEP) in Waterloo, Ontario.

Beginning in May 1999, after being awarded a $220,000 grant from the federal government's Climate Change Action Fund, the REEP began operating. The program was designed "to build public awareness and understanding of the climate-change issue and to provide technical information and social dialogue about the link to personal energy consumption (Parker et al, 2003, p.173). The project also attempted "to empower behavioural change by identifying the sustained benefits of energy efficiency and providing a practical course of action for homeowners to follow" (Parker et al, 2003, p.173).

The REEP relies entirely on citizen action to initiate change. Residents must take the initiative to request and also to initially pay for the approximately $150 home energy audit. Upon doing so they are visited by a certified energy advisor and a student intern from the University of Waterloo who carry out the audit. The REEP staff collect data and carry out a series of tests concerning both the physical properties of the house and its energy intensive devices. Problems and inefficiencies such as drafts, wet windows, inefficient appliances, etc. are addressed and discussed. The collected data are then entered into a computer modeling program. At the end of the evaluation a report is provided to the homeowner that includes suggestions for ways to reduce air leaks, areas where additional insulation may be required, and possible upgrades to doors, windows and appliances in order to save energy. The residence is also given an energy efficiency rating based of the EnerGuide system and participants are asked to fill out a survey to support ongoing university research. The final stage of the project comes once the homeowners have implemented the energy efficiency upgrades. At this time the REEP staff return to the household and conduct a post-retrofit evaluation and provide an upgraded energy efficiency rating for the home (The REEP, 2004).

By engaging community members in energy efficiency dialogue and making practical suggestions to homeowners REEP has been able to pursue its vision of empowering citizens "to contribute to a healthier, more sustainable community while simultaneously furthering Canada's international commitment to the Kyoto Protocol" (Parker et al, 2003, p.173). REEP found that "if all of the proposed upgrades were implemented, average residential energy consumption would be cut by 25 percent and $CO_2$ emissions would be reduced by 18 percent" (Parker et al, 2003, p.175). It is important to note that this figure is far shy of the theoretical potential for efficiency improvements (closer to 60%). Rather than dwelling on what is theoretically possible REEP focused on the more practical target of actions that homeowners would actually be willing to make towards energy efficiency.

Waterloo's REEP, has completed more home energy efficiency evaluations than any other region in Canada. The projects community centered approach "contributed 10 percent of all EGH evaluations nationwide in 1999-2001, despite the region having only 1.4 percent of Canada's population" (Parker et al, 2003, p.177). The project has evaluated and provided recommendations to over 5000 homes to date resulting in "an estimated reduction in greenhouse gas emissions of over 13,683 tonnes per year, a savings to homeowners of over $1.6 million per year in energy costs, and a potential investment in the community for home renovations of $23.7 million" (The REEP, 2004). Parker et al (2003, p.177) argue that "the success of REEP in engaging local homeowners is argued to be a function of active community participation, the

development of local partnerships…and the removal of time, trust and financial barriers to the home-energy evaluation". Whatever the case, the Waterloo REEP's successful accomplishments have been recognized and emulated in similar programs throughout South-Western and South-Central Ontario.

One of the main reasons that Waterloo's REEP was able to succeed was that it had adequate support from all levels of government. As Parker et al (2003, p.178) note the projects "Financial capacity is strengthened by the combination of federal and local resources". The study was initially funded in large part by the EGH and Canada's Climate Change Action Fund. Through these channels the federal government provided a standard fee of $150 for each completed evaluation" (Parker et al, 2003, p.176). Local governments including the cities of Cambridge, Kitchener and Waterloo, have provided additional financial support to maintain the project and keep the costs of the home evaluations affordable.

While the REEP provides an exemplary example of community driven incentives to conserve energy, it is important to note that even if the suggested 25% reduction in participating households was applied to Canada's entire residential sector Kyoto, and more importantly, sustainability targets would not be met. This is "because of the growth in the number of houses, the size of houses and the increased use of electrical devices" (Parker et al, 2003, p.182). Parker et al (2003, p.182) add that for sustainability objectives to truly be met "a significant change in the social context (energy price rises, emission taxes, new policies, etc.) is required to raise the socio-technical potential for residential energy efficiency in Canada" (Parker et al, 2003, p.182). Nonetheless the REEP program is a shining example of how the cumulative actions of individuals can make a remarkable difference.

# 5.0 Analysis of Ontario Situation and Recommendations

In order to achieve a sustainable future it must first be acknowledged that "the current mix of energy sources, energy infrastructure, and energy end-use applications is not efficient enough, diverse enough, or clean enough to deliver the energy services required during this century in a sustainable fashion" (UNDP, 2000, p.419). The transition towards sustainability, or in other words meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, p.8), will require an integrated approach to electricity issues. Such sustainable development also inherently involves "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potentials to meet human needs and aspirations" (Brundtland, 1987, p.46). Gibson (2004, p.5) adds that "a turnaround to sustainability will also require a host of other initiatives to strengthen appropriate incentives, to gain better information and stronger analytical tools, to foster greater humility and to link assessment work with initiatives in complementary areas such as green accounting, sustainability indicator development, corporate social responsibility, ecological tax reform, new approaches to conflict resolution and interdisciplinary education". While the options for achieving a sustainable electricity future in Ontario are numerous and complex, there are guiding principles which may be incorporated into all decision making that improve the chances of achieving a desirable future.

## *5.1 Framework for Evaluating the Alternatives*

While there can be no one template for making complex policy decisions it is possible and indeed beneficial to set out a framework for more sustainable decision making. Within such a framework "the three components of sustainable development - economic development, social development and environmental protection, are to be integrated as interdependent and mutually reinforcing pillars" (UNDP, 2000, p.11). Such broad based criteria may help guide policy makers to "recognize complexity and uncertainty, accept the importance of context and the likelihood of conflict, and still agree that [they] should always think carefully and openly about [their] bases for decision making, and keep decision criteria visible and available for debate" (Gibson, 2004, p.4). Accompanying, or rather fitting in to this framework must be specific contextual factors. For example, when it comes to Ontario's electricity future, among the specific factors to be

considered are "security of supply, adequacy, affordability, reliability, environmental soundness, and preservation of Ontario's economic competitiveness" (Electricity Conservation & Supply Task Force. 2004, p.5). Overall the eight criteria set forth in figure 5.1 Should "serve as the objectives underpinning every serious strategy for enhancing future wellbeing and they should inform the planning and review of every undertaking with potentially significant sustainability implications" (Gibson, 2004, p.25).

***Figure 5.1 Gibson's Sustainability Criteria and Contextual examples***

| |
|---|
| ***Socio-ecological system integrity***<br>Underlying all sustainability initiatives is the need to "build human-ecological relations that establish and maintain the long term integrity of socio-biophysical systems and protect the irreplaceable life support functions upon which human as well as ecological well-being depends" (Gibson, 2004). Traditional electricity generation has proven to have a host of ecologically damaging impacts. Gibson (2004, p.9) suggests the need to "reduce the indirect and overall, as well as direct and specific, threats to system integrity and life support viability" and that "[t]o do this we need to adjust and reconstruct our own human systems to establish more modest, sensitive and flexible relations with the biophysical systems upon which we depend. |
| ***Sufficiency and opportunity***<br>Access to energy services in sufficient quantities is seen as one of the largest prerequisites for economic development. However the paths chosen by current developed nations have caused significant damage to both local and global environmental conditions. True sustainability requires "that everyone and every community has enough for a decent life and opportunities to seek improvements in ways that do not compromise future generations' possibilities for sufficiency and opportunity" (Gibson, 2004). |
| ***Intragenerational equity***<br>While Canada and other developed nations struggle to decide upon and implement sustainable electricity plans, most countries and the majority of the world's people live without adequate energy supply. However, with much of the world population growing rapidly global electricity demand is certain to rise exponentially over the coming decades. Gibson (2004, p.13) points out that "in the dominant institutions of economic authority today, the main strategies for improving conditions for the poorest of the poor are centred on economic growth achieved largely through expansion of material production, consumption and trade". Thus one of the main challenges of sustainability is to "ensure that sufficiency and effective choices for all are pursued in ways that reduce dangerous gaps in sufficiency and opportunity (and health, security, social recognition, political influence, etc.) between the rich and the poor" (Gibson, 2004). Associated issues of greenhouse gasses and global warming are truly global phenomena. Therefore any sustainable electricity futures must also be global in scope. |
| ***Intergenerational equity***<br>The very concept of sustainability and sustainable development dictates that the needs of future generations must not be compromised. Therefore any sustainable decision making must "favour present options and actions that are most likely to preserve or enhance the opportunities and capabilities of future generations to live sustainably "(Gibson, 2004). |
| ***Efficiency***<br>One of the strategies to meeting Ontario's, and indeed the global community's, electricity demands in a sustainable manner will be to implement a much more efficient use of resources and production of wastes. In addition to becoming more efficient, Gibson (2004, p.17) highlights the need to "direct gains to those in material need and to shift the demands of the affluent to less materially and energy intensive satisfactions". Thus while electricity efficiency improvements seem a quick and easy solution, their implementation and long term contribution to true sustainability is often much more complex. |
| ***Democracy and civility***<br>Rather than simply rely upon government decision making bodies and the power of the unregulated free market to lead us to a sustainable future, Gibson (2004) suggests that we must begin to rely more upon the "capacity, motivation and habitual inclination of individuals, communities and other collective decision-making bodies to apply sustainability principles through more open and better informed deliberations, greater attention to fostering reciprocal awareness and collective responsibility, and more integrated use of administrative, market, customary, collective and personal decision-making practices". As a global collective the human race needs to become "more thoughtful, open and flexible, able to examine our capacities and objectives in a more integrated way, with more humility, more far-sightedness, and more commitment to |

continuous learning and adjustment" (Gibson, 2004, p.18).

***Precaution and adaptation***
In sustainability based decision making few things are ever certain and risks ore often unavoidable. Unforeseen consequences may arise from even the most environmentally benign options. Such realities highlight "the virtues of caution, the need for open and multiple processes, and the desirability of taking nothing for granted" (UNDP, 2000, p.438). In addition sustainable decision making must "respect uncertainty, avoid even poorly understood risks of serious or irreversible damage to the foundations for sustainability, plan to learn, design for surprise and manage for adaptation" (Gibson, 2004). Such precautionary approaches aim to create a portfolio of several diverse options rather than "putting all of one's eggs in one basket". Gibson adds that such decision making "prefers safe fail technologies (that can fail without causing serious damage) over fail-safe technologies (that require multiple safety systems because any failure could be catastrophic) [and] favours undertakings that are designed for flexibility and reversibility, that include mechanisms for effective monitoring, and that are accompanied by backup alternatives" (Gibson, 2004, p.22-23).

***Immediate and long term integration***
Gibson (2004, p.23) points out that "the requirements for sustainability are not mere targets for the long run; they are a package of obligatory considerations for all decisions along the way". The sustainable decision making components listed above, much like the traditional environmental, economic and social pillars, are to be integrated in mutually supportive policy frameworks. Therefore the fundamental challenge for sustainable decision making is "to find workable processes for pursuing all of the requirements at once, recognizing the interconnections and seeking positive overall gains even when trade-offs are unavoidable" (Gibson, 2004, p.24).

The above criteria will be used in table 5.3 to evaluate various packages of potential policy options and implementation mechanisms. The likely results and activities from such policies will be examined analyzed based on their key implications for sustainability in both the short and long term.

## *5.2 Analysis of Policy Options Available*

Ontario must begin to implement targeted policies geared towards both increased efficiency and production of new renewable electricity sources before critical windows of opportunity are closed. In addition, current barriers to sustainability must be removed through appropriate government intervention. While the specifics of such policies can be diverse the mechanisms to achieve them can essentially be broken down into three groups: (1) mandatory requirements, (2) labelling, certification and education and (3) fiscal incentives and research and development funding (see table 5.2).

### 5.2.1 Mandatory Requirements

Mandatory requirements are essentially policy measures put in place by government to either promote efficiency or new renewable generation. They may incorporate financial incentives (such as net metering); however, their primary function is to set the rules or introduce legislation to stimulate sustainable activities.

### 5.2.2 Labeling, Certification and Education

Labelling, certification and education programs help to promote and validate renewable electricity sources and efficient products. They add to consumer confidence and knowledge thereby increasing the potential for renewable electricity options.

### 5.2.3 Fiscal Incentives and R&D funding

Renewable energy sources are ultimately the only choice for the future of Ontario's electricity generating sector; however, they "will become prevalent only if they can be more competitive than fossil fuels in terms of relative prices" (Chow et al, 2003, p.1530). Green energy sources remain uncompetitive for several reasons including the continuation of subsidies granted to conventional electricity sources, tax breaks and the absence of "real" costs in electricity pricing. Neglecting the hidden costs, collectively called "externalities", of traditional generation sources represents "a detrimental (or beneficial) effect to a third party for which no price is exacted" (Pearce, 2002, p.58). Externalities have perpetuated the ongoing struggle to allow renewable sources to enter into the provincial electricity system. Therefore, if renewables are to become more prevalent there is an urgent need to phase out conventional subsidies and internalize the hidden costs of traditional electricity sources.

Renewable sources have thus far failed to adequately permeate into the Ontario market because the very resources (air, climate, and human health for example) which they are designed to preserve have no direct market value. Hawken (1993, p.13) points out that "the expense of destroying the earth is largely absent from the prices set in the marketplace" and calls this reality "the single most damaging aspect of the present economic system". The reason that this situation is so troublesome is because, as Pearce (2002, p.64) suggests, if "the asset being depreciated is not being marketed, the problem arises of finding individuals' willingness to pay to prevent those changes". Field (1995 p.6) adds that "a key reason why there are few incentives to take environmental consequences of our actions into account is that ownership of many environmental resources is not possible". Yet it seems certain that "any system will produce destructive environmental impacts if the incentives within the system are not structured to avoid them" (Field, 1995 p.6). In order to begin to make changes it must be acknowledged that decisions made by both producers and consumers of electricity take place "within a certain set of economic and social institutions [and that] these institutions structure the incentives that lead people to make decisions in one direction or another" (Field, 1995 p.5). The expansion of new renewable electricity generation and the adoption of efficiency initiatives will be reliant upon pricing that is based on the full costs of generation and on finding ways to lower the relative cost of renewables.

The essence of an economic incentives approach is "to restructure the incentives facing firms and consumers in such a way that it mobilizes their own energy and ingenuity to find ways of reducing their impacts on the environment" (Field, 1995 p.10). Thus it becomes the role of government to implement policy that can shift market forces from working against the adoption of sustainable electricity sources to working towards these goals and making markets work more effectively. Chow et al. add that in doing so, government programs can "have the same effect as scarcity-induced price increases, and would stimulate (or mandate) new energy technologies that increase efficiency, mitigate pollution, and substitute for fossil energy (2003, p.1530). Unfortunately, policies and legislation in Ontario have not yet adequately addressed these challenges. Guided primarily by the voices of big-business and investors, decision making in the province has failed to support sustainable energy systems and remains primarily short term and near sighted. Government officials at both the provincial and federal levels seem to have acknowledged the need for change.

Traditionally, renewable energy development only occurs in areas where there are high electricity prices or where fiscal policy measures are implemented that promote renewable energy (Clean Air Renewable Energy Coalition [c]. 2004). Since significant raises in energy pricing is undesirable for consumers and un-strategic for politicians, governments are encouraged to rely on what Chow et al (2003, p.1530) call "two coordinated and self-reinforcing actions". The first option is to "adopt a variety of R&D policies (usually in the form of subsidies) that would bring down the price and improve the performance of renewables in comparison with fossil fuels; and, second, they can raise the price of fossil fuels through carbon taxes or permits and thereby tilt the economics towards renewables" (Chow, Kopp & Portney, 2003, p.1530). The use of such financial incentives and disincentives sends a clear message to both power producers and electricity users. A variety of fiscal policies aimed at increasing the use of renewables as well as efficiency are available and have been successfully implemented around the globe (see table 2.5).

The goal of the provincial government must focus on implementing policy that creates "a competitive market [that] will provide the right price signals which will ensure that efficiency measures, renewable energy options and demand side measures are adopted where they are most cost effective" (Diesendorf, 1995, p.33). Recent speeches from Prime Minister Paul Martin and Ontario Energy Minister Dwight Duncan seem to indicate that there is a growing recognition of the importance of incorporating economic incentive approaches into environmental policies; nevertheless, few if any significant steps have been taken thus far.

Finding the "requisite political will and financial support to enact such changes will occur only when societies and their governments decide that the benefits of fossil fuel consumption do

not make up for the negative effects on environmental health and human welfare of fossil fuel dependence" (Chow et al, 2003, p.1531). Hawken (1993, pp.73-74) adds that is "only when the incentives to continue the manufacture of waste are removed, and only when the risks and costs far outweigh the gains and profits, will designers, engineers, chemists, and investors turn their attention to safer alternatives. While the market alone cannot meet the needs of all groups, nor can it adequately and exclusively protect the environment, it can be used as a tool which if supported with appropriate policy steps that allow markets to operate more effectively and more widely may enable renewable sources to begin to be able to compete with traditional fuels.

## *5.3 Future Scenarios - Top packages of alternatives*

In planning for sustainable futures it is useful to envision and compare a series of alternative scenarios that may emerge depending on the choices made by Ontario's policy makers. The development of such scenarios can serve as a planning tool for "capturing different relationships and the evolution of factors that determine future energy trajectories and spatial patterns" (UNDP, 2000, p.335). Sustainable electricity scenarios draw from a new paradigm where expansion no longer refers to an increase in fossil fuel supplies but rather on that of the overall electricity portfolio including generation from cleaner sources; where limits do not refer solely to how much can be produced but rather how much the biosphere can assimilate without adverse impacts; where negative externalities associated with electricity production are acknowledged; and where greater consideration is given to all aspects of electricity use including its impacts on the local as well as global environments both now and in to the future.

As mentioned in section three, a sustainable electricity future for Ontario will likely be dependent upon the combination of efficiency initiatives and a commitment to new renewable generation. However, in order to differentiate between the two objectives the following table examines each package of alternatives independently. It is also often beneficial to compare such sustainable scenarios to one that is sub-optimal, contradictory, or that simply embraces the status quo. As such, table 5.3 illustrates three scenarios for the future of Ontario's electricity sector: The "business as usual path", the "efficiency path", and the "new renewables" path.

***Table 5.2 Implementation Methods and Potential Policy Recommendations***

| METHODS OF IMPLEMENTATION | EXPLANATION | POTENTIAL RECOMMENDATIONS FOR THE GOVERNMENT OF ONTARIO |
|---|---|---|
| | **Mandatory Requirements** | |
| Renewable Portfolio Standard | • A Renewables Portfolio Standard (RPS) is a policy option that ensures a minimum amount of renewable energy is included in the portfolio of electricity resources serving an area. The percentage of renewable energy can start at only slightly more than is currently available and be gradually increased over time. Under a RPS agreement "investors and generators make all the decisions about how to comply, including: the type of renewable energy to acquire, which technologies to use, what renewable developers to do business with, what price to pay, and what contract terms to agree to" (American Wind Energy Association, 1997, p.1). The role of government is limited to certifying credits, monitoring compliance, and imposing penalties if necessary. One key aspect of a RPS policy is that it must include a definition of renewables that is conducive to sustainable development. | • As part of an RPS the government should set minimum standards for renewable energy generation (4,500 MW capacity in place by 2010, and additional calls for supply up to 7,100 MW by 2015 and 9,800 MW by 2020) and request proposals for new supply from wind, upgraded existing or new small scale hydro, solar, the use of waste-generated methane from municipal, agricultural, industrial sources and other low-impact renewable energy sources. |
| System Benefits Charges | • System Benefits Charges (SBC's) represent a way to generate funds from electricity customers that can then be invested back into sustainable initiatives. SBC's are "typically proposed as a volumetric fee on electricity use, such as a cents per kilowatt-hour imposed on all electricity users through their electric rates" (Wiser, Porter & Clemmer, 2000. p.15). | • A SBC of 0.3 cents/kWh should be applied on all electricity sales to finance energy efficiency and low-income assistance programs. |
| Net Metering | • Net metering allows individuals and businesses to small-scale, renewable power sources to generate their own electricity that can then be fed back into the provincial grid when they generate more than they use. | • Current net metering policies should be expanded to include all industrial, commercial, and residential users, and develop specific and clear guidelines for how to "tie in" to the grid. Small scale generation should be encouraged throughout the province. |
| Guaranteed Prices and Feed in Tariffs | • Providing guaranteed prices and contracts for renewable energy developments can remove the inherent financial risks associated with such projects and stimulate significant development in the industry. | • Specific electricity generation payments should be established and provided for each renewable energy option (recognizing factors such as location, market share, and level of technological development). |
| Renewable Energy Certificates | • Renewable Energy Certificates (REC's) represent a way that businesses and private customers can support renewable electricity production even if no sources exist in their immediate surroundings. Buy purchasing certificates from an REC supplier customers can support renewable electricity production and still maintain service from their local retail electricity provider (Hanson & Van Son, 2004, p.1). | • To ensure that all electricity customers have the ability to purchase renewable electricity, the provincial government should promote and provide opportunities for customers to purchase REC's. Policies could also be implemented that would allow businesses to purchase credits in order to offset the environmental impacts of their business. |
| Supportive Policy Frameworks | • An integrated and diverse approach to energy policy issues is required to ensure that "electricity is used as a power source only where lower cost options do not already exist and only in the quantity in which it is needed" (Canadian Institute for Environmental Law and Policy. 2002, pp.8-9). | • Establish a process for the siting of renewable generating facilities.<br>• The provincial Building Code should be amended to require R2000 or equivalent energy efficiency performance for all new buildings by 2010.<br>• The Planning Act should be amended to make energy efficiency design requirements a condition of planning for new developments.<br>• All levels of government should, in their buildings, purchase their electricity needs from renewable energy sources and promote efficiency.<br>• Enact regulations that ensure fair competition and advance public benefits, including meeting the needs of vulnerable customers, protecting the environment, and facilitating the deployment of innovative energy technologies that help in the pursuit of sustainability goals.<br>• A new Ontario Sustainable Energy Authority should be created to lead and coordinate the province's energy efficiency efforts. |
| | **Labelling, Certification and Education** | |
| Labelling Certified Green Electricity | • Green energy certification simplifies customer choice for green electricity by making products easily recognizable. Incorporating certification programs with an energy performance labelling system on purchased electricity as well as consumer goods such as refrigerators allows customers to make informed decisions about the electricity they purchase as well as how they use it. | • The most energy efficient technologies in all sectors and end-uses should be labelled through the Energy Star or other provincial labelling system. |
| Education Campaigns | • Education campaigns geared at both consumers as well as producers of electricity will be essential as the industry makes the transition to renewable sources and actively seeks gains in efficiency. | • Implement a provincial education strategy to train and certify renewable energy specialists and installers, quantify and map all renewable resources available, increase public awareness on renewable energy potential and support programs. |
| Performance Standards | • Updating the national minimum energy performance standards for products such as windows and refrigerators displays a commitment to increasing efficiency | • All distribution utilities should be required to set targets for efficiency gains.<br>• Adopt minimum energy efficiency standards under the Energy Efficiency Act for all major electricity-using devices and equipment.<br>• Develop efficiency standards for equipment not covered by Energy Star. |
| Premium Green Pricing | • Through effective marketing and labelling the willingness of consumers within Ontario to pay a premium for renewable energy may be increased. | • Because renewables may continue to be more costly than traditional sources for some time, "green" pricing of electricity should be readily available for those who choose to purchase it. |
| Voluntary Agreements | • There may be opportunities to, through effective planning, offset some of the province's peak load electricity demand. | • The province should collaborate with the largest provincial users of electricity (e.g. auto and steel manufacturers, mining companies) to identify ways to reduce peak use. |

| Fiscal Incentives and R&D Funding | | |
|---|---|---|
| Financing and incentives | • Due to the often capital intensive nature of renewable generation projects as well as the many factors, including "real and perceived project risks, the small size of renewable energy industry and many renewable energy projects, and dependence on unpredictable government policies to promote renewable energy" financing mechanisms and financial incentives are often necessary (UNDP, 2000, p.264). | • Providing the following financial incentives for the adoption of energy efficient technologies: Grants for high efficiency home and business energy retrofits; sales tax rebates for all Energy Star products and small-scale renewable energy power sources; and, tax credits for industrial energy efficiency equipment and cogeneration systems.<br>• Establish a partnership with utilities, financial institutions, energy service companies, municipalities, and other stakeholders to offer a series of financing mechanisms to assist electricity consumers in all sectors to finance the adoption of energy efficient products and technologies. |
| Emission tax | Emission taxes are intended to charge electricity producers a specified amount for each form of electricity generation based on the amount of pollutants or additional adverse effects from the use of each source. Hawken (1993 p.169) points out that "their underlying purpose is to undo the distortions created by the relentless pursuit of lower prices and to reveal true costs to purchasers". Taxing all forms of electricity generation accordingly (including taxes on sources such as conventional hydro) would encourage "end-use efficiency for all energy users and reflect the wider range of adverse social and environmental impacts implied by different forms of energy" (UNDP, 2000, p.423-424). The successful implementation of such policies will likely depend on setting an initial taxation level and gradually increasing the tax by a predetermined level at specified intervals. Such an approach gives energy users "time to adjust their patterns of investment and use of energy-using devices to less carbon-intensive and more efficient ones, minimizing economic disruption" (UNDP, 2000, p.424). | • Initiate a process with the federal government to quantify the environmental and social costs of all forms of electricity generation and delivery so these costs can be included into the price of each electricity option to better inform investment comparisons. |
| Subsidies, loans and tax exemptions | • The relative prices of renewable electricity may be subsidized rather than, or in conjunction with, taxing undesirable power sources. Such subsidies may be financed through the proposed SBC and may take several forms including production subsidies, investment subsidies, and various indirect means such as preferential tax treatment or technology cost buy down. (UNDP, 2000). Anderson (1997, p.197) points out that "positive externalities may be recognized in public policy through subsidies or tax deductions" (Anderson, 1997, p.198). In such cases a public authority would reward polluters a certain monetary amount for each tonne of emissions reduced starting from a predetermined benchmark level (Field, 1995 p.241). Hawken, Lovins & Lovins (2000, pp.279-280) add that "there's not yet any significant market in saved energy" and that "making markets in saved resources and avoided pollution can support powerful entrepreneurial innovations that turn each obstacle to resource productivity and loop-closing into an opportunity" (Hawken, Lovins & Lovins, 2000, p.280). | Collaborate with the federal government in the establishment of a provincial revolving loan fund to provide interest-free loans to install distributed generation systems in farms, residences and businesses throughout the province. |
| Tradable permits | • Unlike effluent tax policies, a Transferable Discharge Permit approach creates and distributes a new form of property right. Essentially permits are allocated to electric energy producers allowing an established or desirable amount of emissions. Companies are then free to sell and purchase such permits from one another based on their needs. Companies that do not comply with allocated amounts of pollution would be fined. Field (1995 p.250) suggests that from a political standpoint such an approach makes sense as "it is perhaps easier for people to agree on a pollution-control policy that begins by distributing valuable new property rights than by notifying people they will be subject to a new tax". | • A program of tradable permits could, in conjunction with a provincial RPS, be an effective way to stimulate the market for new renewable generation. |
| Increased government funding for R&D | • Proactive solutions to reduce electricity related greenhouse gas emissions and associated environmental problems while meeting the provinces demanded supply will require increased efforts towards government funded research and development. | • Initiate a research and development program for renewable energy technologies that could be funded through the SBC.<br>• Implement a stable funding mechanism to finance the activities of the Sustainable Energy Bureau.<br>• Undertake a design and costing study for a 200,000 unit solar PV roof program modeled on those undertaken in Europe and the United States.<br>• The Government of Ontario should undertake a complete assessment of the potential contributions from onshore and offshore wind generation, small scale hydro, and the use of waste digestion-generated methane.<br>• Forecast power production from renewable sources in order to more effectively dispatch hydro and existing natural gas facilities to provide base load capacity. |

***Table 5.3 Illustrative Packages and Implications for Sustainability***

| POLICY INITIATIVES | RESULTS AND ACTIVITIES | IMPLICATIONS FOR SUSTAINABILITY | SHORT TERM RATING | LONG TERM RATING |
|---|---|---|---|---|
| **DEMAND SIDE ILLUSTRATIVE PACKAGE** | | | | |
| **PACKAGE COMPONENTS**<br>• A **SBC** of 0.3 cents/kWh should be applied to finance energy efficiency and low-income assistance programs.<br>• Current **net metering** policies should be expanded.<br>• The most energy efficient technologies in all sectors and end-uses should be **labelled.**<br>• Implement a provincial **education** strategy.<br>• All distribution utilities should **set targets** for efficiency gains.<br>• Adopt **minimum energy efficiency standards** under the Energy Efficiency Act.<br>• **Quantify the environmental and social costs of all forms of electricity generation** and delivery so these costs can be included into the price of each electricity option.<br>• Collaborate with the federal government in the establishment of a provincial revolving **loan fund**.<br>• Provide **financial incentives** for the adoption of energy efficient technologies such as grants, sales tax rebates and tax credits.<br><br>**POTENTIAL SAVINGS**<br>• Conservative estimates for potential savings from energy efficiency and conservation initiatives suggest that Ontario could reduce demand by approximately 4,500MW by 2010, 9,000MW by 2015 and as much as 12,000MW by 2020 (David Suzuki Foundation, 2004).<br><br>**COST ESTIMATES (CAD$)**<br>• While cost estimates for efficiency initiatives vary, Winfield et al (2004) suggest that electricity reductions are likely to cost approximately $1.36million/MW. This assumption translates into approximately $6.12 billion to reduce demand by 4,500 MW by 2010. While such figures are in line with the costs for many new generation projects, "the savings in energy costs resulting from reduction in energy consumption will pay for more than 96% of the capital costs of the adoption of energy efficient technologies over the long term" (Winfield et al, 2004, p.18). | **ENVIRONMENTAL IMPACTS**<br>• Reduced CO2 and other GHG emissions contributing to Canada's Kyoto goals.<br>**SOCIO-ECONOMIC IMPACTS**<br>• Avoided environmental and health impacts from the construction and operation of new sources of electricity.<br>• Employment benefits from the development, manufacture and installation of efficient technologies.<br>• Increased GDP growth by improving environmental and economic performance. (UNDP, 2000, p.14).<br>**GOVERNMENT/INDUSTRY IMPACTS**<br>• Avoided capital costs of the generation of new sources of electricity.<br>• Programs such as the 100,000 solar roof program may flourish with financial incentives and cost buy downs.<br>• Potential for technological leadership, innovation and improved provincial competitiveness.<br>• Increased competitiveness of business and industry due to more efficient use of energy.<br>**RESIDENTIAL IMPACTS**<br>• Reduced household bills.<br>• Potential higher for initial costs.<br>• Improved housing quality.<br>**ELECTRICITY SECURITY IMPACTS**<br>• Avoided security risks from nuclear power improved reliability of the system achieved by reducing the overall demand.<br>• Without pursuit of efficiency initiatives a supply gap of up to 15,000 MW could emerge by 2020 (Winfield et al, 2004).<br>• Many efficiency initiatives are well suited to match peak periods of use e.g. lighting | ***Socio-ecological system integrity*** **-** Reducing the demand for electricity ensures that adverse social and environmental effects of traditional generation are minimized and helps to maintain the long term integrity of socio-biophysical systems. | √√√ | √√√ |
| | | ***Sufficiency and opportunity*** **–** A more efficient electricity sector is more reliable on a short term basis and preserves non-renewable resources needed for base load supply ensuring access to electricity now and into the future. Efficiency initiatives also tend to create more jobs than supply side counterparts. While such employment may be lower paying than those from new generation projects, they are typically located where people already live, are evenly distributed and offer more continuous employment compared to "boom & bust" patterns. | √√√ | √√√ |
| | | ***Intragenerational equity*** **-** By developing ways to use electricity more efficiently and harmoniously with development goals Ontario may be able to lead the way for other nations, many of which are rapidly industrializing and have exponentially increasing electricity demands. Regretfully, efficiency initiatives often require initial financial investments which may exclude certain low-income households from these and other benefits. | √ | √√ |
| | | ***Intergenerational equity*** **-** Using electricity more efficiently helps to enhance, or at least preserve, opportunities for future generations. | √√ | √√√ |
| | | ***Efficiency*** **–** Using resources more efficiently makes a direct and undeniable contribution to sustainability goals provided that the saved finances are redirected to further efficiency projects, social equity programs, or other positive goals. | √√√ | √√√ |
| | | ***Democracy and civility*** **–** The success of many efficiency initiatives will be directly dependent upon the choices individuals make (e.g. which products to buy or programs to participate in). One key advantage of efficiency initiatives is that they are generally localized and use manageable forms of technology enabling many of the initiatives to be completed by individual homeowners or businesses. | √√ | √√ |
| | | ***Precaution and adaptation*** **–** From a resource standpoint using electricity more efficiently has almost no potential for adverse effects. Moreover, efficiency allows for more flexibility and diversification of the overall grid. There is however potential for efficiency targets to not be met and without precautionary planning supply shortages could result. | √√ | √ |
| | | ***Immediate and long term integration*** **–** Efficiency initiatives may be rapidly implemented and have tremendous and long lasting potential for savings. Many such programs and actions promise multiple, mutually reinforcing gains. Furthermore, such policies and programs are not path dependent or restrictive and can easily be integrated along side new renewable generation projects into an overall sustainable electricity framework. | √√√ | √√√ |

| POLICY INITIATIVES | RESULTS AND ACTIVITIES | IMPLICATIONS FOR SUSTAINABILITY | SHORT TERM RATING | LONG TERM RATING |
|---|---|---|---|---|
| **SUPPLY SIDE ILLUSTRATIVE PACKAGE** | | | | |
| **PACKAGE COMPONENTS**<br>• As part of an **RPS** the government should set minimum standards for renewable energy generation (4,500 MW by 2010, and up to 7,100 MW by 2015 and 9,800 MW by 2020).<br>• A **SBC** of 0.3 cents/kWh should be applied on all electricity sales.<br>• Specific **guaranteed electricity generation payments** should be established and provided for each renewable energy option.<br>• Implement a provincial **education** strategy.<br>• **"Green" pricing** of electricity should be readily available.<br>• Establish a partnership to offer a series of **financing mechanisms.**<br>• **Quantify the environmental and social costs of all forms of electricity generation** and delivery so these costs can be included into the price of each electricity option.<br><br>**POTENTIAL GENERATION**<br>• It has been estimated that Ontario could harvest up to 8,000MW of wind generated electricity by 2012, 1000MW of low impact hydro by 2020, as much as 2,450MW of electricity from biomass by 2020 and up to 1250MW of photovoltaic electricity by 2025 (David Suzuki Foundation, 2004). Such figures are certainly attainable with supportive policy frameworks in place. For example Germany was able to add 2,645MW of wind generated electricity in 2003 alone.<br><br>**COST ESTIMATES (CAD$)**<br>• The cost of implementing renewable forms of generation varies depending on the source of electricity, the size of the application and a number of other project specific factors. However, an estimated cost for wind generated electricity is $1.5 million/MW ($6.75 billion for 4,500MW) and approximately $1 million/MW of small scale hydro or biomass generation ($4.5 billion for 4,500MW) (Winfield et al, 2004). | **ENVIRONMENTAL IMPACTS**<br>• Reduced CO2 and other GHG emissions contributing to Canada's Kyoto goals.<br>• Offsets the need for new nuclear and associated hazardous materials.<br>**SOCIO-ECONOMIC IMPACTS**<br>• Avoided environmental and health impacts from the construction and operation of traditional sources of electricity.<br>• Modular design of most renewable production allows facilities and any associated employment to be created where needed as opposed to centralized.<br>• It is estimated that approximately 20,000 new jobs will be created as early as 2015 in pursuing renewable production in Ontario (Clean Air Renewable Energy Coalition [b]. 2004).<br>**GOVERNMENT/INDUSTRY IMPACTS**<br>• Potential for technological leadership, innovation and establishment of a renewables based industry.<br>**RESIDENTIAL IMPACTS**<br>• While the prices of electricity may, at least on a short term basis, need to be raised to reflect the costs of renewable generation they are likely to be reduced as the industry becomes more established and as government savings are re-invested into the industry.<br>• Net metering may allow individual homeowners to generate electricity and lower bills.<br>**ELECTRICITY SECURITY IMPACTS**<br>• Avoided security risks from nuclear power<br>• Improved supply efficiency as renewable generating facilities can be located closer to where electricity is needed.<br>• Electricity prices, while potentially higher, will be more stable over the long term.<br>• Renewable electricity generation is more flexible, adaptable, and in most cases diversified than traditional "path dependent" sources.<br>• By pursuing and gaining experience with renewable technologies Ontario, and indeed Canada, may be able to accelerate technological diffusion to the rapidly developing world. | ***Socio-ecological system integrity –*** Shifting to renewable sources of electricity generation reduces the adverse impacts (such as mining for traditional carbon based fuel sources and the production of GHG's and contribution to global warming) of traditional generation. | √√√ | √√√ |
| | | ***Sufficiency and opportunity –*** There is significant potential in Ontario to meet much of the province's electricity needs from renewable sources. Such renewable generation also offers the potential for community economic development through employment opportunities that are more widely distributed and longer lasting than those related to traditional generation. For example the Clean Air Renewable Energy Coalition estimates that up to 20,000 new jobs could be created in Ontario if renewable options are pursued. There is however the potential for short-term unemployment to occur in communities formerly dependant on the centralized generation facilities of coal fired generation stations. | √√ | √√√ |
| | | ***Intragenerational equity –*** Pursuing renewable options and the associated benefits displays Ontario's commitment to a more sustainable global environment. Moreover, as renewable technologies become more widely used and as costs decline these technologies can be implemented in much of the developing world where the modular characteristics may help to ensure global access to electricity. | √√√ | √√√ |
| | | ***Intergenerational equity -*** Pursuing renewable options for electricity generation helps to ensure that the needs of future generations will not be compromised. | √√ | √√√ |
| | | ***Efficiency –*** Renewable production creates significantly more electricity per unit of waste than do traditional sources. Such generation is also more efficient at supplying electricity as facilities can be located closer to end users limiting losses through the distribution process. | √√ | √√ |
| | | ***Democracy and civility -*** Commitment towards a renewable electricity sector for Ontario will increasingly enable individuals and communities to demonstrate their commitment to a sustainable future in meaningful ways. For example, supportive policies may enable individual homeowners or businesses to produce their own renewable electricity. Community driven projects such as Toronto's "Windshare" turbine may also become more common. | √√ | √√√ |
| | | ***Precaution and adaptation –*** By investing in a diverse portfolio of renewable options (including wind, hydro, biogas and solar) Ontario's electricity sector will be more flexible and adaptable to future demands and uncertainties. In addition, while traditional sources of electricity such as that from nuclear power have potential for catastrophic effects, renewable options are far less likely to have any significant consequences. Some have however suggested that renewable generation facilities are unpredictable and may contribute to future supply concerns. | √√ | √√ |
| | | ***Immediate and long term integration –*** Renewable initiatives, once approved, may be rapidly implemented. They offer long lasting potential for reduced emissions and electricity costs. Furthermore, renewable options tend to be proposed as a package of options that can easily be integrated along side efficiency initiatives into an overall sustainable electricity framework. | √√ | √√√ |

| POLICY INITIATIVES | RESULTS AND ACTIVITIES | IMPLICATIONS FOR SUSTAINABILITY | SHORT TERM RATING | LONG TERM RATING |
|---|---|---|---|---|
| **BUSINESS AS USUAL DEVELOPMENT PACKAGE** | | | | |
| **PACKAGE COMPONENTS**<br>• Continue along the current trajectory maintaining roughly the same sources of electricity (Nuclear 40%, coal 25% and hydro 25% with some limited amount of additional renewable generation and efficiency.<br>• Invest in new nuclear or invest further into restarting nuclear power generation.<br>• Pursue incremental policy options towards the development of new renewable generation.<br>• Continue to derive the majority of the province's electricity from centralized generating stations.<br><br>**POTENTIAL GENERATION**<br>• The generation potential of traditional sources of electricity (most likely nuclear or natural gas) does not realistically appear to be limited by anything other than capital considerations for at least the next century.<br><br>**COST ESTIMATES (CAD$)**<br>• Much like renewable generation the cost of traditional generation options varies widely depending on the specifics of the project. While combined cycle natural gas plants can be built for approximately $1 million/MW new nuclear generation facilities cost at least $2.1 million/MW. This translates into an estimated cost ranging from $4.5 billion for 4,500MW of CCNG to $9.45 billion for the same amount of new nuclear power. Other options such as natural gas generation and the refurbishment of existing nuclear facilities is likely to fall somewhere in between these figures (Winfield et al, 2004). | **ENVIRONMENTAL IMPACTS**<br>• Maintained or increased levels of CO2 and other GHG emissions contributing to global warming.<br>• Need for new nuclear and associated hazardous materials.<br>**SOCIO-ECONOMIC IMPACTS**<br>• Maintenance of traditional jobs in non-renewable generation.<br>• Temporary creation of new jobs while generation facilities are built.<br>• Environmental and health impacts from the construction and operation of traditional sources of electricity.<br>**GOVERNMENT/INDUSTRY IMPACTS**<br>• Unlikely to meet legally binding Kyoto targets.<br>• Nuclear power is heavily "path dependent" and limits the viability of future options.<br>• Limited potential for innovation.<br>**RESIDENTIAL IMPACTS**<br>• Potentially volatile electricity prices that are likely to rise.<br>• Few cost savings achieved through efficiency initiatives.<br>**ELECTRICITY SECURITY IMPACTS**<br>• Security risks from nuclear power.<br>• Traditional forms of generation must be built as large, centralized plants to be economical. They therefore require longer timelines and forecasting ability. | ***Socio-ecological system integrity* -** Traditional electricity generation has proven to have a host of ecologically damaging impacts. | | |
| | | ***Sufficiency and opportunity* -** While traditional electricity sources are likely to maintain current jobs they offer limited potential for any increase in long-term employment levels. Without embracing efficiency initiatives, regardless of the methods of generation chosen, Ontario faces very real potential for supply shortages. | √√ | √ |
| | | ***Intragenerational equity* –** Traditional sources of electricity certainly offer the potential to deliver electricity in sufficient quantities to Ontario's population. However, reliance on such sources only exacerbates current socio-economic problems related to the supply of electricity in Ontario and offers no assistance or alternatives for developing nations around the world. | √√ | |
| | | ***Intergenerational equity* –** Non-renewable electricity sources deplete resources, contaminate the biosphere and do not contribute towards long term sustainability goals. | | |
| | | ***Efficiency* –** Neglecting to aggressively pursue efficiency initiatives increases the likelihood of supply shortages for the province. In addition, traditional sources of electricity generation are subject to significant efficiency losses as electricity travels from centralized stations to far off end users. | | |
| | | ***Democracy and civility* –** A business as usual approach to Ontario's electricity sector limits the choices and options that businesses and communities have to contribute to a sustainable future. Opportunities are likely to be limited to lobbying for increased efficiency and renewable generation. | | |
| | | ***Precaution and adaptation* –** Although traditional generation options, such as that of nuclear power, offer a fairly predictable output of electrical energy they are less flexible and adaptable than a diverse package of options. Furthermore, reliance on such sources introduces the potential for significant consequences such as nuclear disasters and also neglects increasing evidence that climate change is likely to have severe impacts on the biosphere. | √ | |
| | | ***Immediate and long term integration* –** Traditional generation projects require fewer institutional or structural changes to the existing grid. However, such projects (especially new nuclear facilities) often take many years to begin generating. In addition investments in nuclear technology are likely to be exclusive of renewable projects and contribute very little to long term sustainability goals. | √ | |

Based on the above table it seems that electricity options that embrace new renewables as well as efficiency and conservation initiatives are far more desirable, over both the short and long term, than traditional options. These options seem to offer at least the potential for greatly increased incorporation of key sustainability principles (i.e. socio-ecological integrity, equity, sufficiency, etc) and are therefore vital for the future of Ontario's electrical energy system.

## *5.4 Potential Barriers*

A number of significant institutional barriers stand in the way of the development of renewable technologies and of increased efficiency measures in Ontario. These barriers, which could be overcome by appropriate frameworks and policies, include:

- Economic risks (such as competing land uses, the amount and timing of solar irradiation, environmental concerns, and wind patterns).
- Taxation and regulatory obstacles.
- Lack of adequate information, technical knowledge, and training.
- Uncertainties about the performance of investments in new and energy-efficient technologies.
- Lack of adequate investment capital or financing possibilities.
- High initial and perceived costs of more efficient technologies.
- High transaction costs (for searching and assessing information and for training).
- Longer payback periods (up to four years or more)
- External costs of energy use, not included in energy prices.
- Patterns and habits of consumers, operators, and decision-makers, which may be influenced by many factors, including ideas of social prestige and professional norms.

*Sources: (UNDP, 2000, Clean Air Renewable Energy Coalition [b], 2004 & Canadian Institute for Environmental Law and Policy. 2002).*

In addition, overall public support for action on climate change continues to waver as the "fear of potential loss of livelihood, lowering of living standards, and perceived threats to vital support systems and other elements of the social fabric continue to inhibit the formation of a broad consensus over climate change" (ICFTU & TUAC, 2004, p.1). Such fears may not be entirely unfounded as "sector-by-sector and regional analyses indicate turbulent times in the short term, as large numbers of workers will lose jobs and livelihoods, with little access to new jobs that will be created" (ICFTU & TUAC, 2004, p.2). However, in the long run a sustainable electricity sector, in addition to the numerous other benefits, offers more potential for sufficiency and opportunity of employment, especially if fair transition mechanisms are implemented, and therefore must be pursued.

# 6.0 Future Direction

## *6.1 Conclusions*

The various packages presented in table 5.3 represent only some of the many policy options that could be implemented by the government of Ontario. Their purpose is to illustrate that efficiency initiatives are both possible and desirable, that renewable generation is preferable to many forms of traditional generation and that policy goals should be diverse, flexible, as well as highly adaptable. A sustainable electricity sector will require a pluralistic approach. Not only will a variety of sources need to be harnessed, but a number of different implementation mechanisms will need to be used (including market incentives, mandatory requirements, education and R&D). These goals will not be achieved through policies, funding and incentives alone. While all of these are absolutely necessary, success can only be achieved if individuals embrace sustainability goals both in theory and in practice.

A sustainable electricity future for Ontario must strive for socio-ecological system integrity through supply and demand channels that require reduced use as well as increased production from renewable sources. Sufficiency and opportunity must be pursued in ways that ensure access to electricity now and into the future and that stimulate evenly distributed and long lasting employment opportunities. Accomplishing these goals will require increased reliance on fair transition mechanisms as well as forecasting in order to understand in advance any negative employment or social impacts. Such forecasting may ensure that undesirable impacts can be "equitably managed within an overall programme in which environmentally-damaging production is prevented or minimised, and positive change is promoted and reinforced" (ICFTU & TUAC, 2004, p.3). The pursuit of sustainability goals should be spurred on not only by current domestic interests but also by the opportunity to provide leadership towards sustainable energy futures for developing nations around the globe. Furthermore, sustainability must inherently seek out to promote intergenerational equity by enhancing, or at the very least, preserving opportunities for future generations.

While technological advancements, increased knowledge and experience all but assure that eventually global economic growth will outpace increases in energy consumption leading to a less energy intensive and more efficient society, delaying this supposed inevitability is certain to have tremendous costs. Immediately using resources more efficiently makes a direct and undeniable contribution to sustainability goals provided that the saved finances are redirected to further efficiency projects, social equity programs, or other positive programs. Targeted government policies to promote and fully recognize the legitimacy of electrical efficiency must be accompanied by education campaigns and indeed the good will of individuals (Torrie & Parfett, 2003). Democracy and civility are needed, for as Hawken (1993, p.136) suggests "an ethic is not an ethic, and a value not a value, without some sacrifice for it, something given up, something not taken, something not gained. We do it in exchange for a greater good for something worth more than just money

and power and position". The greater good in this case is an electrical system that is both precautionary and adaptable to future demands and uncertainties.

With immediate and long term goals in place Ontario can begin to implement its sustainable electricity vision through a range of policy options and implementation mechanisms. Commonalities between such options include the need to formulate clear goals and targets, to address and remove the various barriers to the deployment of renewables, as well as to internalise the environmental costs and other externalities associated with competing conventional options (UNDP, 2000). In addition, the provincial government must work to establish transparent market conditions that encourage investment, create temporary incentive mechanisms that secure grid access for renewable electricity sources and increase funding for efficiency initiatives and R&D. Kyoto Protocol goals and already established mechanisms may serve as a catalyst to the aforementioned activities and help to increase public awareness and support (regionally as well as globally) for efficiency and renewables. To become pervasive, renewable electricity and efficiency issues must be integrated into non-energy sector policies and cross-sector issues such as transportation, economic development as well as urban and land use planning (Renewables 2004, 2004). Finally, because of the inertia of current energy systems, and because energy systems change slowly, in order "to assess what kinds of development will ultimately be sustainable, one must have a global perspective and a very long time horizon covering periods of at least a century" (UNDP, 2000, p.336). Therefore perhaps the most important guiding component for the future of Ontario's electricity sector will be a consistent political commitment towards a sustainable electricity future.

## *6.2 Future Study: Global Sustainability – Canada's International Role*

While the focus of this paper has been on options for Ontario's electricity future it is of utmost importance to acknowledge that the socio-economic problems which a sustainable electricity policy aims to address are global in scale and that, as Brown et al (1991, p.150) suggest "the world as a whole has a growing stake in the ability to marshal an environmentally sustainable development effort". The reality is that "a small minority of the global population accounts for most economic activity, materials use, and mobility…but many of the adverse environmental and other impacts of this cumulative energy consumption have been shared with the rest of the world" (UNDP, 2000, p.352). While electricity use in Ontario and most of the developed world is now taken for granted some two billion people around the world have no access to electricity (Glazov, 2003). Furthermore, by the year 2100 it is predicted that "6–8 billion additional people—significantly more than today's world population—will need access to affordable, reliable, flexible, and convenient energy services" (UNDP, 2000, p.18). The developing world will require improved energy efficiency as well as abundant, reliable and affordable electricity if it is to achieve greater opportunities, prosperity, health and environmental quality (Brown et al., 1991, Driessen, 2003). Therefore a sustainable electricity future for Ontario or Canada must extend beyond national borders. For it is "the rich countries,

including Canada, that have the most room, technological knowledge and wealth to take the first steps in creating a new energy-environmental mix" (Crane, 2004).

To address the needs of the global community will require immediate, proactive planning and solutions. For unless "an early start is made on changing direction, the delay will almost certainly result in additional costs" (UNDP, 2000, Pp.417-418). A sustainable solution to the developing world's energy supply woes cannot come from traditional sources such as coal fired electrical plants and "simply importing advanced technologies from industrialized countries – even if affordable – is unlikely to suffice" (UNDP, 2000, p.435). The UNDP (2000, p424) points out that policy steps may need to be taken to "discourage relocation of heavily emitting activities ('carbon leakage'), including barriers in international trade rules to the import and use of the resulting materials and products to ensure global benefits" (UNDP, 2000, p.424). Meanwhile those in the developing world believe that for "developed countries to suggest that such policies are ethical, socially responsible or environmentally beneficial is to engage in hypocrisy and delusion" (Driessen, 2003). While solar panels and small scale wind turbines are often touted as a solution, they are unlikely to provide the quantity of electricity that these communities and nations need (Driessen, 2003). In the mean time, generation from biomass sources contributes to deforestation and a host of additional ecological impacts as well as air pollution from cooking and heating fires (Glazov, 2003). The issues surrounding electricity supply, perhaps the most critical link between the environment and development, pose serious ethical dilemmas that must be addressed. These realities, bleak as they may seem, should serve as further motivation for Ontario, and indeed the entire developed world, to learn about and pursue the most practical ways of achieving a sustainable electricity future.

## Appendix A: Glossary of Terms

DSM: Demand-Side Management

EGH: EnerGuide for Houses

GHG: Greenhouse gas

GWH: Gigawatt hours – A measure of electric current equivalent to one thousand megawatts hours.

HEPC: Hydro-Electric Power Commission

IMO: Independent Electricity Market Operator

kWh: kilowatt hour - A measure of electric current equivalent to one thousand watts being used continuously for a period on one hour.

MW: Megawatt - A measure of electric current equivalent to one million watts.

OEIFC: Ontario Electricity Financial Corporation

OPG: Ontario Power Generation

PV: Photovoltaic

R&D: Research and Development

REC's: Renewable Energy Certificates

REEP: Residential Energy Efficiency Program

RPS: Renewables Portfolio Standard

SBC's: System Benefits Charges

TREC: Toronto Renewable Energy Co-operative

UNCED: United Nations Conference on Environment and Development

UNCHE: United Nations Conference on the Human Environment

UNDP: United Nations Development Programme

UNFCCC: United Nations Framework Convention on Climate Change

WCCA: World Conference on the Changing Atmosphere

WSSD: World Summit on Sustainable Development

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A submission to the OPA from Permanent Power Solutions, an Ontario based company specializing in renewable energy.

When it comes to producing energy we have to acknowledge some basic truths. Affordable and readily available energy is crucial to the economy of our province. Energy rules, it is that simple.

We can no longer be content with a status quo as our current generating system is in dire need of an overhaul. Aging and outdated generating stations and a capacity that is too often stretched to the limit. Despite energy conservation measures the demand for energy keeps going up. Our population growth dictates that energy demands grow proportionally. In an ideal world all energy comes from one source and the process is neat and simple. Unfortunately we are not living in an ideal world.

We are pleased that the OPA is acknowledging a new reality. Some of our old systems are not living up to the hype with which they were introduced. Bigger is not always better and alternatives do exist. It is with a sense of growing alarm that we are starting to accept the fact that squandering non-renewable resources to produce energy, is not only wasteful, it is a practice that has to cease. We have to preserve our non-renewable resources for the industrial processes that generate the wealth for the people of this province.

Oil fuels our economy and without oil we don't have an economy. We need to preserve the black and it is time to go green. The technology to convert to renewable energy is here. Going green, using wind and solar and other renewable resources will not be easy. There are limitations to what renewable energy can and can not do. Doing without energy however is not an alternative either.

One of the things we have to acknowledge is the fact that we need to fragment the industry into smaller components, allowing private generators to compliment our existing generating stations. When it comes to generating energy Ontario has to adapt, we have no choice.

The challenge to switch over to renewable energy to power our homes, industries and transportation is tremendous – but it can be done! Not stepping up to the plate is akin to abandoning our role of industrial leadership and allowing other nations to forge ahead with their plans of changing the ways in which we produce electricity.

The added bonus is not only the addition of thousands of new jobs in all the processes of renewable energy generation and all its applications, but an important step forward towards the proper stewardship of our planet and our commitment as a nation to live up to the principles of the Kyoto Accord.

We need to create an environment that encourages a rapid introduction to green energy. When oil replaced the horse we reluctantly embraced a changing society and a way of life. Once we embraced the industrial age we did so with a great deal of enthusiasm and a lot of faith.

And again the time has come for all of us to make some drastic changes, to learn to live with various energy models, some specifically tailored to meet the demands of a particular geographic area or group. We need to rise to this challenge and to this new reality.

The people of this province are looking at our government for direction and leadership, for incentives and programs that will encourage the investment in energy alternatives. Rather than going into specific details about programs that we feel will benefit the conversion to green sources of energy, we would like to use this report as a voice of encouragement and support.

Permanent Power Solutions focuses on the rural areas and many of our customers are committed to changing over to renewable energy. Our customers are farmers and small businesses and rural homeowners. At the present time we are not doing enough to promote programs and incentives that will see a much more rapid conversion. There is a pent up demand and we need to seize the momentum to invest in a diverse energy market.

We urge OPA to take a serious look at the opportunity that small businesses and farmers can make to relieving the stress on our power grid by either producing their own energy or contributing the excess to the grid.

Our overall goal has to be clean, affordable energy. We have the technology. It is time for all of us to embrace new energy attitudes and approaches to ensure a safe and plentiful energy supply for this province.

We thank you for attention and time and for the opportunity to present this submission.

Signed

Bill Bes, author and energy analyst on behalf of Permanent Power Solutions

Subject: Ontario energy supply

Hello,
I understand that you are accepting input regarding Ontario's target energy supply mix.
Please accept my ideas on this subject, as a student in law and environmental studies.

1) Nuclear should not even be an option.
I understand that we are turning back to nuclear because it is clean burning, and because some facilities already exist.
This can only be a temporary solution, due to the limited supply of uranium, but also because it continues to foist our problems off on the next generation. This cycle of shifting problems to future generations has to end at some point. Why not now? People fear nuclear- it is not a politically strong option either. I understand that we need a temporary solution to our increased power demands, but nuclear must and can be just that- temporary.

2) Coal is simply not an option. It must be phased out, for the sake of our health, and our quality of life.

3) Renewable energy has not been given serious consideration to this point.

I agree wholeheartedly with the recommendations of the Clean Air Alliance, that we must aim for 60% renewable energy by 2020.
Canada is sorely lacking in investment in renewable energy, especially when compared to European nations.
Ontario, as a centre of industry in Canada, and a site of hydroelectric resources, could be a leader in this regard.

I am truly concerned about the future of our energy supply.
It is my generation that will inherit the escalating environmental costs of our energy use today.
Please do not let the legacy of this government be increased smog or nuclear waste. Make a commitment to renewable energy.

Thank you for your time.
Sincerely,
Andrea Bradley

**Subject:** Renewable energy sources please!

I understand you are currently seeking public input regarding recommendations you will be making to the Minister of Energy for Ontario's future electricity supply mix.

I urge you to recommend that the majority of our electricity supply should come from renewable sources as quickly as possible, but definately within the next 10 years.

Thank you.

Cathie Brenner

AUG 17 2005

Bruce Power™

ORIG: Neil Freeman
COPY: Jan Carr
Amir Shalaby

August 11, 2005

Duncan Hawthorne
President & Chief Executive Officer

Ontario Power Authority
Attention: Supply Mix Submissions
175 Bloor Street East
North Tower, Suite 606
Toronto, Ontario
M4W 3R8

To whom this may concern,

I would like to take this opportunity to recognize your request for written submissions addressing a number of issue areas for the Ontario Power Authority (OPA) with respect to Ontario's energy supply mix over the next 20 years.

On June 27, 2003 the Electricity Conservation & Supply Task Force (ECSTF) was formed with the task of developing an action plan for attracting new generation, promoting conservation and enhancing the reliability of the transmission grid.

As a member of the ECSTF, I believe our assessment was very comprehensive in nature and the recommendations represented a strong consensus from many key players across Ontario's energy sector.

I believe that the government of the day made a concerted effort to ensure the task force consisted of representatives from the supply, distribution, consumption and conservation sectors in the Ontario energy market. This diverse mixture of representation allowed the task force to develop recommendations that captured every aspect of Ontario's energy picture.

Even through the report was published in January, 2004 I believe it addresses many of the issues your organization is looking at today given your mandate under the Electricity Act. I would be happy to discuss the recommendations in the ECSTF report or any other supply mix issues with you at any time.

Regards,

Duncan Hawthorne

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Adopted

# STATE OF CALIFORNIA

**CONSUMER POWER AND CONSERVATION FINANCING AUTHORITY**

**ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION**

**PUBLIC UTILITIES COMMISSION**

## ENERGY ACTION PLAN

California is a diverse and vibrant society. The fifth largest economy in the world, California's population is expected to exceed 40 million by 2010. California's economic prosperity and quality of life are increasingly reliant upon dependable, high quality, and reasonably priced energy. Following the biggest electricity and natural gas crisis in its history, the state is well aware of the need for stable energy markets, reliable electricity and natural gas supplies, and adequate transmission systems. Looking forward, it is imperative that California have reasonably priced and environmentally sensitive energy resources to support economic growth and attract the new investment that will provide jobs and prosperity throughout the state.

California's principal energy agencies have joined to create an Energy Action Plan. It identifies specific goals and actions to eliminate energy outages and excessive price spikes in electricity or natural gas. These initiatives will send a signal to the market that California is a good place to do business and that investments in the more efficient use of energy and new electricity and natural gas infrastructure will be rewarded. This approach recognizes that California currently has a hybrid energy market and that state policies can capture the best features of a vigorous, competitive wholesale energy market and renewed, positive regulation. This approach will be ever mindful of the need to keep energy rates affordable, and is sensitive to the implications of energy policy on global climate change and the environment generally.

While this Plan lays out specific actions, it is a living document. It is a blueprint that is subject to change over time. The agencies will use it to give their efforts direction, focus, and precision, but some of the specific actions cited are subject to further proceedings so may need to be fine-tuned or changed to best meet the overall goals.

## Energy Action Plan Goal

The goal of the Energy Action Plan is to:

> **Ensure that adequate, reliable, and reasonably-priced electrical power and natural gas supplies, including prudent reserves, are achieved and provided through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers.**

The energy agencies intend to achieve this through six specific means:

- Meet California's energy growth needs while optimizing energy conservation and resource efficiency and reducing per capita electricity demand.
- Ensure reliable, affordable, and high quality power supply for all who need it in all regions of the state by building sufficient new generation.
- Accelerate the state's goal for renewable resource generation to 2010.
- Upgrade and expand the electricity transmission and distribution infrastructure and reduce the time before needed facilities are brought on line.
- Promote customer and utility owned distributed generation.
- Ensure a reliable supply of reasonably priced natural gas.

## The Agencies are Accountable for Stewardship of California's Energy Future

The state's principal energy agencies are committed to active and continued cooperation. This is unprecedented. To implement this Energy Action Plan agencies pledge:

- To discuss critical energy issues jointly through open meetings and ongoing informal communication.
- To share information and analyses to minimize duplication, maximize a common understanding and ensure a broad basis for decision-making.
- To bring joint policy recommendations about major energy issues to the Governor and Legislature.

The state needs to guide development of the energy system in the public's best long-term interest, to anticipate potential problems, and to make timely decisions to resolve problems. Specifically, the agencies commit to:

- Provide decision-makers impartial assessments of the state's immediate and long-term electricity and natural gas demands, resources, and prices.
- License and, where necessary, fund construction of new energy facilities that are consistent with the reliability, economic, public health, and environmental needs of the state.
- Ensure that the utilities are able to carry out their obligation to serve, including having adequate reserves, recognizing this is a critical component of the current hybrid energy system.

- Restore investor and private sector confidence in California's energy markets.
- Develop an "early warning" system to alert policy makers of potential future problems.
- Work with FERC to redesign market rules and prevent manipulation of the energy markets.
- Partner with governmental and other groups in western North America to pursue commonly held energy goals.
- Make continuing progress in meeting the state's environmental goals and standards, including minimizing the energy sector's impact on climate change.

**Shared Principles and Strategies Will Guide this Stewardship**

Achieving the overall goal and implementing the proposed actions require close cooperation between the state's energy agencies and means establishing and following common principles and strategies. In particular, the agencies intend to use market forces and regulatory approaches to operate the system in the best, long-term interest of the public: the consumers, the ratepayers, and the taxpayers. This means agency actions will attract private investment into California's energy infrastructure to stretch and leverage public funds and consumer dollars. The agencies must also provide appropriate regulatory guidance, price signals, and incentives to all Californians to use energy efficiently. The agencies will achieve rate stability and provide affordable energy, particularly for low-income consumers, through progressive rate design.

To protect the public's health and safety and ensure our quality of life, the agencies support the most cost-effective and environmentally sound strategies, including consideration of global climate change. The agencies also will work to ensure that low-income populations do not experience disproportionate adverse impacts from the development of new energy systems.

**The Agencies' Approach Will be Open and Timely**

Achieving the overall goal requires thoughtful planning, followed by specific, timely actions. This process begins with an ongoing assessment of the current and future energy system and the state's economic needs. It must consider a range of risks and uncertainties and must identify and inform policy makers of potential shortfalls and vulnerabilities. The agencies and state policy makers need to respond by carefully considering available options, balancing costs and benefits to meet state goals, selecting policy choices, and devising actions to implement those policy choices.

The result must be a set of interrelated actions that complement each other, provide risk protection, and eliminate the costs and conflicts that would occur if each agency pursued isolated, uncoordinated objectives. Each agency will need to implement the action plan in its individual proceedings but in concert with each other.

For the action plan to achieve the desired outcomes, it must rely on a common vision and be based on an integrated energy resource plan indicative of the state's future energy needs. The Energy Commission's integrated energy assessment process, as

set forth by the Governor and Legislature last year in SB 1389, represents a critical step in identifying future statewide energy needs. The agencies will participate in this process, assessing demand growth and available supply, and balancing various state policy objectives to determine the combination of conservation and infrastructure investments that best meet California's short- and long-term needs. The Public Utilities Commission and the Power Authority will carry out their energy-related duties and responsibilities based upon the information and analyses contained in the assessment.

The Action Plan envisions a "loading order" of energy resources that will guide decisions made by the agencies jointly and singly. First, the agencies want to optimize all strategies for increasing conservation and energy efficiency to minimize increases in electricity and natural gas demand. Second, recognizing that new generation is both necessary and desirable, the agencies would like to see these needs met first by renewable energy resources and distributed generation. Third, because the preferred resources require both sufficient investment and adequate time to "get to scale," the agencies also will support additional clean, fossil fuel, central-station generation. Simultaneously, the agencies intend to improve the bulk electricity transmission grid and distribution facility infrastructure to support growing demand centers and the interconnection of new generation.

**Energy Services are Growing, are Essential, and the Delivery Systems are Complex**

As a context for this plan, Californians must understand the essential and complex nature of the state's energy resources. Currently the state uses 265,000 gigawatt-hours of electricity per year. Consumption is growing 2 percent annually. Over the last decade, between 29 percent and 42 percent of California's in-state generation used natural gas. Another 10 - 20 percent was provided by hydroelectric power that is subject to significant annual variations. Almost one third of California's entire in-state generation base is over 40 years old. California's transmission system is aging also. While in-state generation resources provide the majority of California's power, California is part of a larger system that includes all of western North America. Fifteen to thirty percent of statewide electricity demand is served from sources outside state borders.

Peak electricity demands occur on hot summer days. California's highest peak demand was 52,863 megawatts and occurred July 10, 2002. Peak demand is growing at about 2.4 percent per year, roughly the equivalent of three new 500-megawatt power plants. Residential and commercial air conditioning represent at least 30 percent of summer peak electricity loads.

California's demand for natural gas also is increasing. Currently the state uses 2 trillion cubic feet of natural gas per year. Historically the primary use of this fuel was for space heating in homes and businesses. Electricity generation's dependence on relatively clean-burning natural gas now means that California's annual natural gas use by power plants is expected to increase. Overall, natural gas use is growing by 1.6 percent per year. Eighty-five percent of natural gas consumed in California is supplied

by pipelines from sources outside the state.

## Six Actions

The agencies propose six sets of actions of critical importance that need to be undertaken now. These are:

### *I. Optimize Energy Conservation and Resource Efficiency*

California should decrease its per capita electricity use through increased energy conservation and efficiency measures. This would minimize the need for new generation, reduce emissions of toxic and criteria pollutants and greenhouse gases, avoid environmental concerns, improve energy reliability and contribute to price stability. Optimizing conservation and resource efficiency will include the following specific actions:

1. Implement a voluntary dynamic pricing system to reduce peak demand by as much as 1,500 to 2,000 megawatts by 2007.[1]
2. Improve new and remodeled building efficiency by 5 percent. [2]
3. Improve air conditioner efficiency by 10 percent above federally mandated standards.[3]
4. Make every new state building a model of energy efficiency.
5. Create customer incentives for aggressive energy demand reduction.
6. Provide utilities with demand response and energy efficiency investment rewards comparable to the return on investment in new power and transmission projects.
7. Increase local government conservation and energy efficiency programs.
8. Incorporate, as appropriate per Public Resources Code section 25402, distributed generation or renewable technologies into energy efficiency standards for new building construction.
9. Encourage companies that invest in energy conservation and resource efficiency to register with the state's Climate Change Registry.

### *II. Accelerate the State's Goal for Renewable Generation*

In 2002, the Governor signed the Renewable Portfolio Standard (RPS), SB 1078. This standard requires an annual increase in renewable generation equivalent to at least 1% of sales, with an aggregate goal of 20% by 2017. The state is aggressively implementing this policy, with the intention of accelerating the completion date to 2010,

[1] . California is actively evaluating and implementing such pricing systems in a CPUC rulemaking (R.02-06-001).
[2] The Energy Commission's 2005 building standards, to be adopted in 2003, when combined with training and enforcement, are expected to reduce energy needs in new buildings by approximately 5 percent.
[3] New federal appliance standards will increase air conditioner efficiency by approximately 20 percent, but if California were granted a waiver from federal standards, by 2007 California air conditioner efficiency would increase another 10 percent.

and will:

1. Add a net average of up to 600 MW of new renewable generation sources annually to the investor-owned utility resource portfolio.[4]
2. Establish by June 30, 2003, key RPS implementation rules, including market price benchmarks, standard contract terms, flexible compliance and penalty mechanisms, and bid ranking criteria under the "least cost-best fit" rubric. Other key RPS rules will be developed and refined throughout 2003.
3. Facilitate an orderly and cost-effective expansion of the transmission system to connect potential renewable resources to load.
4. Initiate the development of RPS compliance rules for energy service providers and community choice aggregators.
5. Coordinate implementation with all relevant state agencies and with municipal utilities to facilitate their achievement of the standard.

### *III. Ensure Reliable, Affordable Electricity Generation*

The state needs to ensure that its electrical generation system, including reserves, is sufficient to meet all current and future needs, and that this reliable and high quality electricity comes without over-reliance on a single fuel source and at reasonable prices. To these ends the state will:

1. Add new generation resources to meet anticipated demand growth, modernize old, inefficient and dirty plants and achieve and maintain reserve levels in the 15 percent-18 percent range.[5] Current estimates show a statewide need for 1500 - 2000 MW per year.[6]
2. Finance a few critical power plants that the agencies conclude are necessary and would not otherwise be built. An estimated 300 MW of peaking capacity located in critical areas is needed to provide local reliability, help achieve adequate reserves, and reduce congestion and the need for new transmission lines.[7]

[4] Electricity sales by the Investor-owned utilities totaled about 169,000 GWh in 2001. The renewables portfolio standard requires an annual increase in renewable generation equivalent to 1 percent of sales, or about 1,700 GWh. Assuming a capacity factor of about 50 percent, this is roughly equivalent to 385 MW. Accelerating achievement of the RPS goal to 20 percent by 2010 would mean adding 4,200 MW of renewables over 7 years, or 600 MW (1.6 percent) per year. California is implementing the Renewable Portfolio Standard for the Investor-owned utilities in a PUC rulemaking (R.01-10-024).

[5] The Western Electricity Coordinating Council (WECC) has established minimum operational requirements of loss-of-load probability of no more than one day in ten years. Current information suggests that the WECC criteria can be met with approximately 15 – 18 percent reserve margins.

[6] Peak demand growth is expected to be approximately 1,400 MW per year for the next two years, depending on weather and other factors. California is evaluating statewide generation resource needs in the CEC development of the Integrated Energy Policy Report (02-IEP-01).

[7] The CAISO in 2002 identified generation-deficient areas and sub-areas within its control area, such as the greater Bay Area, Humboldt, Battle Creek and Vaca Dixon. Although some of these constraints may be solved by transmission improvements, it may prove more cost-effective to add new generation in some areas perhaps utilizing the CPA's authority to finance new power plants.

3. Work with the California Independent System Operator (CAISO) to implement generator maintenance standards and an oversight process to support coordinated availability of generation.[8]
4. Work with the CAISO to ensure the development of a workable, competitive wholesale energy market that has meaningful market power mitigation rules.
5. Monitor the electricity market to identify any exercise of market power and manipulation, and work to improve FERC-established market rules to correct any observed abuses.

### *IV. Upgrade and Expand the Electricity Transmission and Distribution Infrastructure*

Reliable and reasonably priced electricity and natural gas, as well as increasing electricity from renewable resources, are dependent on a well-maintained and sufficient transmission and distribution system. The state will reinvigorate its planning, permitting, and funding processes to assure that necessary improvements and expansions to the distribution system and the bulk electricity grid are made on a timely basis:

1. The agencies will collaborate, in partnership with other state, local, and non-governmental agencies with energy responsibilities, in the California Energy Commission's integrated energy planning process to determine the statewide need for particular bulk transmission projects. This collaboration will build upon the California Independent System Operator's annual transmission plan and evaluate transmission, generation and demand side alternatives. It is intended to ensure that state objectives are evaluated and balanced in determining transmission investments that best meet the needs of California electricity users.
2. The Public Utilities Commission will issue an Order Instituting Rulemaking to propose changes to its Certificate of Public Convenience and Necessity process, required under Public Utilities Code § 1001 et seq., in recognition of industry, marketplace, and legislative changes, like the creation of the CAISO and the directives of SB 1389. The Rulemaking will, among other things, propose to use the results of the Energy Commission's collaborative transmission assessment process to guide and fund IOU-sponsored transmission expansion or upgrade projects without having the PUC revisit questions of need for individual projects in certifying transmission improvements.
3. The Public Utilities Commission will ensure that IOUs build out and properly staff and maintain distribution systems to meet California's growth, provide reliable service, and stand ready to restore service after unplanned distribution system outages.
4. The Energy Commission will work with municipal utilities to help ensure completion of transmission expansion or upgrade projects in their systems for which the collaborative transmission assessment process finds a need.

[8] California is undertaking this effort in a PUC rulemaking (R.02-11-039).

## *V. Promote Customer and Utility Owned Distributed Generation*

Distributed generation is an important local resource that can enhance reliability and provide high quality power, without compromising environmental quality. The state is promoting and encouraging clean and renewable customer and utility owned distributed generation as a key component of its energy system. Clean distributed generation should enhance the state's environmental goals. This determined and aggressive commitment to efficient, clean and renewable energy resources will provide vision and leadership to others seeking to enhance environmental quality and moderate energy sector impacts on climate change. Such resources, by their characteristics, are virtually guaranteed to serve California load. With proper inducements distributed generation will become economic.

1. Promote clean, small generation resources located at load centers.
2. Determine whether and how to hold distributed generation customers responsible for costs associated with Department of Water Resources power purchases.
3. Determine system benefits of distributed generation and related costs.
4. Develop standards so that renewable distributed generation may participate in the Renewable Portfolio Standard program.
5. Standardize definitions of eligible distributed generation technologies across agencies to better leverage programs and activities that encourage distributed generation.
6. Collaborate with the Air Resources Board, Cal-EPA and representatives of local air quality districts to achieve better integration of energy and air quality policies and regulations affecting distributed generation.
7. The agencies will work together to further develop distributed generation policies, target research and development, track the market adoption of distributed generation technologies, identify cumulative energy system impacts and examine issues associated with new technologies and their use.

## *VI. Ensure Reliable Supply of Reasonably Priced Natural Gas*

The high and volatile price of natural gas contributed significantly to the energy crisis in 2000-2001, and concerns about manipulation of the market and scarcity persist. The Governor's Natural Gas Working Group was formed to monitor natural gas demand, supply and price issues and facilitate the construction of California infrastructure projects. Yet California remains vulnerable to the volatile spot market. The agencies will pursue the following actions:

1. Identify critical new gas transmission, distribution and storage facilities needed to meet California's future needs.
2. Monitor the gas market to identify any exercise of market power and manipulation, and work to improve FERC-established market rules to correct any observed abuses.
3. Evaluate the net benefits of increasing the state's natural gas supply options, such as liquefied natural gas.
4. Support electric utilities and gas distribution companies entering into longer-term contracts as a hedge against volatile and high spot market prices.

In implementing this plan, the agencies are mindful that energy services – both natural gas and electric – are essential to every Californian's general welfare and to the health of California's economy. As actions to improve the reliability of these services are considered, the agencies will each take into account the effect the action will have on energy expenditures, the environment and climate change, and the overall economy. Alternatives to proposed actions will be evaluated in an integrated fashion, consider the cost of action or inaction, and consider the equitable distribution of costs among customer classes and groups.

While implementation of this Action Plan represents a challenge, it is an important step for the agencies to take together to help achieve the state's overall goal of adequate, reliable, and reasonably priced electrical power and natural gas supplies.

Adopted May 8, 2003 by a 3-2 vote of the CPUC. Dissent of Commissioners Lynch and Wood attached.

Adopted April 30, 2003 by unanimous vote of the CEC.

Adopted April 18, 2003 by unanimous vote of the CPA.

**Dissent of Commissioners Lynch and Wood to the Energy Action Plan, May 8, 2003, Item CR-2**

Coordination among agencies is good. Cooperation among agencies is good. Planning is good. All of these aspects of the Action Plan are positive. However, there is a difference of emphasis and philosophy that makes the document unsupportable at present. Our focus is on consumers. The Plan's focus is on competition. We want stability, predictability, consumer protection, low prices, environmental preservation, and regulatory fairness. The Plan talks about markets. We want to re-establish and strengthen the utilities' obligation to serve. The Plan wants to cultivate hybrid markets. We want to promote distributed renewables and new efficient, low-polluting, utility-owned generating plants. The Plan offers generic support for customer-owned generation in any form.

We want to ensure that utilities make wise economic choices when procuring or generating power. The plan wants to use "proper inducements" to help various kinds of distributed generation technologies to become economical. This is a euphemism for ratepayer provided subsidies. We want to restore investor confidence in California's regulated utilities. The plan talks of restoring investor confidence in California's energy markets. Stable energy markets, reliable energy supplies and adequate transmission systems are all admirable goals, standing alone, they miss the point if they do not explicitly address the needs of the California consumers.

We want to vigorously oppose FERC's efforts to invade areas of state jurisdiction. The Plan wants to work with FERC to redesign markets. We want to use the tools of regulation to provide consumers with the products and prices they desire. The Plan talks about continuing to rely on market forces to provide at least part of the answer.

Where one stands on these issues makes all of the difference when answering fundamental questions about energy planning and service. Someone who looks at an inkblot and sees markets will argue for higher reserve margins and redundant transmission facilities – adding billions of dollars in cost. One who looks at the same image and sees the face of a consumer will be searching for ways to keep costs low and stable, make supplies efficiently reliable, and support integrated planning and least-cost dispatch. It is this fundamental difference that drives the debate about such things as transmission adequacy and ISO rule changes. None of us may be so wedded to one vision that all of our choices will be true to a single course. However, the proposed Energy Action Plan steers straight down a path leading to deregulated energy markets. We do not agree that the Commission should take California consumers down this road and will not vote to support the Action Plan in its current form.

***We have a further concern involving process that is fundamental. Where the Energy Plan reflects the expression of goals and an approach for moving***

***forward, it is welcome, appropriate and even necessary. However, where it attempts to prescribe specific outcomes for matters that require evidentiary records and careful scrutiny, it goes too far.***

What is good and appropriate in terms of coordination and planning is perhaps reflected best by the section that addresses gas reliability and prices. In this section, the agencies commit to identify needed new facilities, monitor the market to guard against the exercise of market power, evaluate the net benefits of new supply options such as LNG, and support the appropriate use of long-term supply contracts to stabilize prices. These are broad goals that could appropriately frame the activities of the agencies without prejudging the outcome of formal proceedings.

But what the ad hoc subcommittee and this commission cannot do is to form advance commitments to decide in a certain way matters that must come before the agency. This is not a limitation of philosophy or style. It is a limit imposed by law.

Here are some examples of ways in which the Plan moves beyond appropriate planning and coordination. It sets goals for peak demand reduction through a variable pricing system. It does this, although it acknowledges that the Commission is actively evaluating such pricing systems in a pending proceeding. It declares an appropriate capacity range for new electric resource additions and an appropriate range for reserve margins although the Commission has yet to take the steps required by AB 57 before establishing such goals. Similarly, it jumps ahead of the AB 57 process to declare a level of needed new peaking capacity.

It declares that three specific new transmission projects are needed even though the Commission is required by law to make record-based needs assessments under Section 1001 and CEQA. One of the projects, the Path 15 upgrade, is the subject of two draft decisions that are currently pending before the Commission. The other two – a second Palo Verde-Devers line and an expansion to serve wind farms in Tehachapi -- are as-of-yet not even the subject of formal applications. It announces that sufficient new transmission must be built to ensure high quality power supply throughout the state, although those nice-sounding words suggest that the entire state should be wired as if it is the Silicon Valley. It prejudges the Commission's decision about departing load customers and pledges the adoption of exemptions for various technologies at levels not represented by any Commission orders.

We fear that some commissioners show an impatience for action that reflects more than a desire for government to act quickly. We are concerned that it reflects a desire to lock the agency into positions and commitments before it is burdened by such niceties as the facts in an evidentiary record and parties' interpretations of the law and policy.

In an apparent effort to answer this concern, the current draft contains a warning label, declaring that specific proposed actions may need to be fine-tuned or changed. However, this message is transparent. If the subcommittee did not intend for specific numbers to have meaning, then it would not have included them in the document. If the

signers did not intend for certain construction projects to be approved, then they would not have included words calling for their approval. As the disclaimer further states, this is a "blueprint", intended to provide "direction, focus, and precision". The obvious goal is to predetermine either the specific outcome or the substantive direction of various proceedings currently pending, or expected to be filed. We cannot pledge, in advance, to lower someone's rates in a certain way, deny someone's complaint, or approve someone's petition. Nor can we skirt around pending proceedings to create new programs, set reserve margins or declare that certain new facilities are needed. To do so would be unfair. It would breed cynicism and it would violate the law. For these reasons, we cannot and will not support the adoption of the Energy Action Plan.

/s/ LORETTA M. LYNCH
Loretta M. Lynch
Commissioner

CARL WOOD
Carl Wood
Commissioner

San Francisco, California
May 8, 2003

# STATE OF CALIFORNIA

**ENERGY COMMISSION**

**PUBLIC UTILITIES COMMISSION**

# ENERGY ACTION PLAN II

## *IMPLEMENTATION ROADMAP FOR ENERGY POLICIES*

**[DATE]**

## I. INTRODUCTION AND SUMMARY

In 2003, the three key energy agencies in California – the California Energy Commission (CEC), the California Power Authority (CPA), and the California Public Utility Commission (CPUC) – came together in a spirit of unprecedented cooperation to adopt an "Energy Action Plan" (EAP)[1] that listed joint goals for California's energy future and set forth a commitment to achieve these goals through specific actions.

The EAP was a "living document" meant to change with time, experience, and need. The CPUC and the CEC have jointly prepared this Energy Action Plan II to identify the further actions necessary to meet California's future energy needs.[2] EAP II supports and expands the commitment to cooperation among state agencies embodied in the original EAP and reflected in the State's coordinated actions over the past two years. The development of EAP II has benefited from the active participation of the Business, Transportation, and Housing Agency, the Resources Agency, the State and Consumer Services Agency, the California Independent System Operator (CAISO), the California Environmental Protection Agency (Cal-EPA), and other agencies with energy-related responsibilities.

EAP II describes a coordinated implementation plan for state energy policies that have been developed through the Governor's Executive Orders, instructions to agencies, public positions, and appointees' statements; the CEC's Integrated Energy Policy Report (IEPR); CPUC and CEC processes; the agencies' policy forums; and legislative direction. This plan will be revised, as needed, to reflect the Governor's formal energy plan and his response to the CEC's IEPR, as well as any changes in responsibilities resulting from the proposed energy agency reorganization.

In preparing EAP II, we do not assume that work undertaken in EAP I is complete or, conversely, to dismiss the significance of the accomplishments to date from EAP I. Rather, EAP II is intended to look forward to the actions needed in California over the next few years, and to refine and strengthen the foundation prepared by EAP I. Appendix A provides a status report on the progress of the EAP I activities to date.

Our overarching goal is for California's energy to be adequate, affordable, technologically advanced, and environmentally-sound. Energy must be reliable – provided when and where needed and with minimal environmental risks and impacts. Energy must be affordable to households, business and industry – and in particular to disadvantaged customers who rely on us to ensure they can afford this fundamental commodity. Our actions must be taken with clear recognition of cost considerations and trade-offs in order to ensure reasonably priced electricity for all Californians. We need to develop and tap advanced technologies to achieve these goals of reliability, affordability and an environmentally-sound energy future. These goals affirm the original objectives of EAP I.

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[1] EAP I can be viewed at the CPUC's website at <http://www.cpuc.ca.gov/PUBLISHED/REPORT/28715.htm> or at the CEC's website at <http://www.energy.ca.gov/energy_action_plan/2003-05-08_ACTION_PLAN.PDF>.

[2] The Consumer Power and Conservation Financing Authority was a co-agency in EAP I. Funding for the agency was eliminated in SB 1113 (Chesbro) Chapter 208, the 2004-2005 budget. No additional funding is proposed in the Governor's 2005-2006 budget.

The State will achieve these goals by taking specific and measurable actions throughout California's energy sector. EAP II expands the original scope from electricity and natural gas to include transportation fuels, reflecting the importance of these energy resources to California's economy and the potential environmental impacts of their use. It also emphasizes that research, development and demonstration activities are critical to realizing our energy goals. In addition, EAP II highlights the importance of taking actions in the near term to mitigate California's contributions to climate change.

EAP II continues the strong support for the "loading order" – endorsed by Governor Schwarzenegger – that describes the priority sequence for actions to address increasing energy needs. The loading order identifies energy efficiency and demand response as the State's preferred means of meeting growing energy needs. After cost-effective efficiency and demand response, we rely on renewable sources of power. To the extent efficiency, demand response and renewable resources are unable to satisfy increasing energy and capacity needs, we support clean and efficient fossil-fired generation. Concurrently, the bulk electricity transmission grid and distribution facility infrastructure must be improved to support growing demand centers and the interconnection of new generation, both on the utility and customer side of the meter.

We also see the need to provide open, transparent, and compelling information and education to all stakeholders and consumers in the State. The agencies are committed to providing more effective information dissemination through increased cooperation among all branches of government, businesses, and energy organizations. In particular, we pledge to remove remaining barriers to transparency in the procurement processes in the State and to increase outreach to consumers by providing improved education and services regarding energy efficiency, demand response, rates, climate change, and the opportunities to reduce the environmental impacts of energy use.

The Energy Action Plan is intended as an implementation roadmap for the entire State. While some of the electricity and natural gas actions are described in the context of the investor-owned utilities, in general they should be seen as applying equally to the customer-owned utilities and energy service providers.

Once this new EAP is adopted, the next step will be to prepare a workplan to ensure accountability for each of these key actions items, to determine the specific roles that will be played by each agency, and to develop a timeline that ensures prompt attention to these actions.

## II. SPECIFIC ACTION AREAS

### 1. Energy Efficiency

As stated in EAP I and reiterated here, energy efficiency is the resource of first choice for meeting California's energy needs. Energy efficiency is the least cost, most reliable, and most environmentally-sensitive resource, and minimizes our contribution to climate change. California's energy efficiency programs are the most successful in the nation and we want to continue to build upon those successes.

For the past 30 years, while per capita electricity consumption in the US has increased by nearly 50 percent, California electricity use per capita has been approximately flat. This achievement is the result of continued progress in cost-effective building and appliance standards and ongoing enhancements to efficiency programs implemented by investor-owned utilities (IOUs), customer-owned utilities, and other entities. Since the mid-1970s, California has regularly increased the energy efficiency requirements of new appliances sold and new homes and buildings constructed here. In addition, in a creative and precedent-setting move, the CPUC in the 1980s de-coupled the utilities' financial results from their energy sales, facilitating utility support for efficiency programs. These efforts have saved more than 10,000 MW of peak capacity and continue to save about 35,000 GWh per year of electricity.

However, to achieve the full energy efficiency potential that exists in California, we must continue to ratchet up our efforts. We need to focus not only on developing and supporting programs, but also on increasing public outreach and education; promoting research, development, and demonstration; and pursuing the evaluation, measurement, and verification of efficiency programs.

**KEY ACTIONS:**

1. Expand efforts to improve public awareness and adoption of energy efficiency measures, with special attention given to low income, non-English speaking, and other hard-to-reach communities.
2. Adopt IOU and third party 2006-2008 energy efficiency program portfolios and funding by late 2005.
3. Promote cost-effective energy efficiency programs that target peak demand and integrate energy efficiency programs with demand response programs in order to provide all consumers a variety of approaches to reducing their energy usage and energy bills.
4. Implement actions outlined in the Governor's Green Buildings Action Plan to improve building performance and reduce grid-based electrical energy purchases in all State and commercial buildings by 20 percent by 2015.[3]
5. Adopt new appliance standards by 2006, supplementing those adopted in December 2004.
6. Adopt new building standards for implementation in 2008 that consider, among other measures, demand response technologies, integrated photovoltaic systems, and other clean on-site generation.
7. Increase the availability of State-sponsored low-interest loans for energy efficiency and clean distributed generation projects.
8. Add verifiable performance incentives in 2006 for IOU energy efficiency investments that are comparable to incentives for supply investment options.

[3] See Executive Order S-20-04, dated December 14, 2004, at <http://www.dot.ca.gov/hq/energy/ExecOrderS-20-04.htm>.

9. Update utility evaluation, measurement and verification protocols so that energy efficiency is fully integrated into resource planning, emission reduction benefits are quantified, and compliance goals are verified.
10. Work with customer-owned utilities in the development of energy efficiency programs to pursue all cost-effective energy efficiency savings as a resource and to ensure that California reaches the EAP I goal of a one percent reduction in per capita energy use.
11. Identify and support opportunities to reduce electricity demand related to the water supply system during peak hours and opportunities to reduce the energy needed to operate water conveyance and treatment systems.
12. Adopt by fall 2005 the report on efficiency in existing buildings required by Assembly Bill 549 and pursue legislation and regulations to implement its findings.

## 2. Demand Response

California is in the process of transforming its electric utility distribution network from a system using 1960s era technology to an intelligent, integrated network enabled by modern information and control system technologies. This transformation can decrease the costs of operating and maintaining the electrical system, while also providing end-use customers with accurate information on energy use, time of use, and cost. With the implementation of well-designed dynamic pricing tariffs, California can lower consumer costs and increase system reliability. In order to achieve this transformation, state agencies will ensure that appropriate, cost-effective technologies are chosen, emphasize public education regarding the benefits of such technologies, and develop tariffs and programs that result in cost-effective savings.

**KEY ACTIONS:**

1. Issue decisions on the proposals for statewide installation of advanced metering infrastructure for all small commercial and residential IOU customers by early 2006.
2. Adopt, as appropriate, dynamic pricing tariffs for summer 2006, emphasizing critical peak pricing tariffs for customers with advanced metering systems and encouraging load shifting that does not result in increases in overall consumption.
3. Educate Californians about the time sensitivity of energy use and the benefits and effects of dynamic pricing tariffs.
4. Create standardized mechanisms to measure and evaluate demand response to ensure savings are verifiable.
5. Ensure that the utilities' demand response investment opportunities offer returns commensurate with investments in traditional plant and distribution systems.
6. Integrate demand response into retail sellers' procurement efforts.
7. Incorporate demand response appropriately and consistently into the planning protocols of the CPUC, the CEC, and the California ISO.

8. Encourage the integration of demand response programs into the ISO's operations.
9. Coordinate demand-response programs with customer-owned utility demand-response efforts to ensure a comprehensive, statewide contribution to California's resource adequacy portfolio.

## 3. Renewables

California can reduce its greenhouse gas emissions, moderate its increasing dependence on natural gas, and mitigate the associated risks of electricity price volatility by aggressively developing renewable energy resources to meet the Renewable Portfolio Standard (RPS) requirements. As originally established, the RPS requires 20 percent of IOU energy sales to come from renewable sources by 2017. In the first EAP, we set a goal of accelerating the 20 percent target from 2017 to 2010. We are now identifying the steps necessary to achieve that target, as well as Governor Schwarzenegger's higher goal of 33 percent of electricity sales by 2020. To reach these goals, we must streamline and make transparent our approval processes, ensure that funding for renewable resources reflects these policy priorities, and provide the necessary infrastructure for delivery of power from new renewable projects. We intend that our increasing reliance on renewable resources in California and the western region will help mitigate energy impacts on climate change and the environment. We expect that all California load serving entities will contribute to these goals.

**KEY ACTIONS:**

1. Expeditiously approve contracts from the initial IOU RPS solicitations and interim renewable solicitations and approve agreements for any necessary supplemental energy payments.
2. Approve and expedite the IOU RPS solicitations for 2005 and the next three years to ensure that California will meet the accelerated RPS goal of 20 percent renewables by 2010.
3. Consider improvements to the renewables solicitation process, as necessary.
4. Develop a comprehensive resource development and regulatory policy reform plan for cost-effectively achieving the Governor's goal of reaching 33 percent renewables by 2020 and ensure that the utilities' continuously work toward this goal.
5. Monitor and support, as necessary, existing renewable resources, including facilitating re-powering projects and addressing contract renewals in a timely fashion.
6. Ensure new transmission lines are built to access renewable resources through a comprehensive, integrated transmission planning process, including the creation of state-led study groups to examine tapping particular resource regions.

7. Implement a cost-effective program to achieve the 3,000 MW goal of the Governor's "Million Solar Roofs" initiative.[4]
8. Implement RPS standards for energy service providers and community choice aggregators to ensure all load serving entities are contributing proportionally to California's renewable goals.
9. Work with customer-owned utilities in the development of their renewable plans and incorporate their results in a comprehensive statewide review to ensure that California reaches its renewable energy goals.
10. Study and take mitigating action to address the effects of increasing penetration of renewables on the reliable operation of the electricity grid and ensure that procurement and operation protocols do not discriminate against renewable resources.
11. Complete the Western Renewable Generation Information System to accurately account for renewable generation through an electronic certificate tracking system.
12. Consider and, if appropriate, implement a renewable energy certificates trading system for meeting RPS goals.

## 4. Electricity Reliability and Infrastructure

Significant capital investments are needed over the next decade to augment existing facilities, replace aging infrastructure and ensure that California's electrical supplies will meet current and future needs at reasonable prices without over-reliance on a single fuel source. Even with the emphasis on energy efficiency, demand response, and renewable resources, investments in conventional power plants will be needed. The State will work to establish a regulatory climate that encourages investment in environmentally-sound conventional electricity generation resources.

An expanded, more robust electric transmission system is required to mitigate grid congestion and bring new renewable and conventional power plants on line. Transmission planning and permitting processes must move projects through planning and into construction in a timely manner. The state agencies must work closely with the CAISO to achieve this objective and to benefit from its expertise in grid operation and planning. Finally, the distribution system, which has the most direct effect on reliable service for consumers, must be continually upgraded and reinforced.

### KEY ACTIONS:

1. Ensure that all load serving entities meet the state's adopted reserve and resource adequacy requirements of a 15-17 percent planning reserve by June

[4] View the Governor's press release at <http://www.governor.ca.gov/state/govsite/gov_htmldisplay.jsp?sCatTitle=Press%20Release&sFilePath=/govsite/spotlight/august20_update.html>.

2006 through a reasonable mix of short-, medium- and long-term resource commitments.

2. Ensure the continued operation of existing generation needed to meet current reliability needs, including highly-efficient combined heat and power generation.
3. Encourage the development of cost-effective, highly-efficient and environmentally-sound supply resources to ensure reliability and consistency with the State's energy priorities.
4. Provide appropriate incentives for the development and operation of new generation to gradually replace the least efficient and least environmentally-sound of California's aging power plants.
5. Manage California's aging electricity infrastructure to coordinate maintenance and outages and to provide orderly retirements.
6. Develop and adopt a long-term policy for existing and new qualifying facility resources, including better integration of these resources into CAISO tariffs.
7. Ensure adequate investment in the utility distribution system, with an emphasis on translating those expenditures into higher levels of reliability.
8. Encourage development of environmentally-sound distributed generation projects, including combined heat and power resources.
9. Develop and implement an integrated, comprehensive, statewide transmission planning process that eliminates bottlenecks, improves reliability, and accesses new renewable resources and coordinate the state process with regional efforts in the interconnected western states.
10. Establish a statewide transmission corridor planning process to create and protect critical transmission corridors for potential development in the future.
11. Develop an improved methodology to expedite siting and certification review of proposed transmission projects while simultaneously conducting a thorough environmental review of all projects.
12. Apply the environmental adder as a resource selection criterion in IOU procurement decisions to more appropriately value the risk of future environmental regulation in long-term investment decisions made now.

## 5. Electricity Market Structure

To promote dependable, affordable, environmentally-responsible wholesale and retail markets, the agencies must foster sound market rules, increase regulatory certainty, and improve coordination with the rest of the West's electrical system. These goals are not possible without working closely with the CAISO, which plays the fundamental role of operating most of California's electricity grid and its critical energy markets. The agencies will continue to cooperate with and assist the CAISO in its core missions.

Californians pay some of the highest utility rates in the nation and the State must take action to decrease overall retail energy bills and to reform rate structures while providing consumers tools to manage their energy usage. The agencies will work to reduce total retail energy bills by

supporting programs for energy efficiency, demand response, and self-generation; ensuring that utility supply portfolios promote the delivery of energy at the least cost; and increasing education and outreach about energy usage. Partnering with private industry, the State will also identify, assess, and, where appropriate, implement actions, such as the development of capacity markets, to enhance reliability and promote investment in energy infrastructure serving California.

**KEY ACTIONS:**

1. Restructure the IOU rate-making process to reduce the number of proceedings, create more transparency in consumer electricity rates, and adopt rates based on clear cost-causation principles.
2. Complete and refine, as necessary, the current IOU electricity procurement process to ensure that it is transparent, open and fair, proceeds in a timely fashion, and achieves California's resource adequacy requirements.
3. Complete and implement by February 2007, the CAISO's Market Redesign and Technology Upgrade to reform California's wholesale electricity market and to ensure adequate market mitigation to protect California consumers.
4. Develop rules to promote an effective core/non-core retail market structure, including mechanisms to guard against cost-shifting, preserve reliability, pursue energy efficiency goals, achieve RPS goals, and maintain the loading order for all load serving entities.
5. Consider the development of capacity markets, including possible tradable capacity rights and obligations, to create appropriate incentives and flexibility for power plant development and utility procurement.

### 6. Natural Gas Supply, Demand, and Infrastructure

To ensure reliable, long-term natural gas supplies to California at reasonable rates, the agencies must first work to reduce or moderate demand for natural gas. Because natural gas is becoming more expensive, and because much of electricity demand growth is expected to be met by increases in natural gas-fired generation, reducing consumption of electricity and diversifying electricity generation resources are significant elements of plans to reduce natural gas demand and lower consumers' bills. California must also promote infrastructure enhancements, such as additional intrastate and interstate pipeline capacity serving the State and increased in-state storage capacity, and diversify supply sources to include access to liquefied natural gas (LNG) facilities.

**KEY ACTIONS:**

1. Adopt additional natural gas efficiency programs and standards to reduce the reliance on natural gas for various end uses.
2. Establish a program to encourage solar hot water heating to reduce the reliance on natural gas for water heating.
3. Ensure that the natural gas delivery system is sufficient to meet California's peak demand needs.

4. Support the development of additional in-state natural gas storage to enhance reliability and mitigate price volatility.
5. Support the State's LNG Interagency Permitting Working Group and a process to facilitate the prompt and environmentally-sensitive evaluation and siting of needed LNG facilities.
6. Establish standards for the timing of and payment for new capacity additions and for firm rights to transmission access.
7. Evaluate the appropriateness of current rules for natural gas quality.

**7. Transportation Fuels** Supply, Demand, and Infrastructure

The fuels used in the transportation of California's goods and population constitute a third facet of our energy sector, in addition to electricity and natural gas. Today, California's gasoline and diesel markets are characterized by increasing demands, tight supplies, and high and volatile prices. California imports about half of its petroleum and petroleum products and its dependence on this increasingly expensive energy resource continues to grow. Moreover, fossil fuel-based transportation of products and people is a major contributor of carbon dioxide, the principal catalyst to climate change. California must find ways to reduce its use of oil in all cost-effective manners, such as driving more fuel-efficient gasoline and diesel vehicles, adopting new automotive technologies such as hybrids and fuel cells, pursuing non-petroleum fuels such as electricity and biofuels, reducing single-passenger vehicle commutes, and relieving congestion. At the same time, we must ensure sufficient and economic supplies of gasoline and diesel to sustain California's economic vitality.

**KEY ACTIONS**

1. Support state legislation that establishes a goal and time frame for reducing California's dependence on petroleum fuels, including a process for measuring and reporting progress toward this goal.
2. Develop and implement strategies to achieve the alternative fuel goals adopted by the CEC and the Air Resources Board to have 20 percent use of alternative fuels in the on-road fleet by 2020 and 30 percent by 2030.
3. Establish a coalition with other states and stakeholders to convince the federal government to double the Corporate Average Fuel Economy (CAFE) standards.
4. Support federal legislation to allow the purchase of high-efficiency hybrid, gasoline, and diesel vehicles in meeting the fleet procurement rules of the Energy Policy Act.
5. Increase the use of high-efficiency and dedicated non-petroleum-fueled vehicles in state and local fleets, identify cost-effective opportunities to expand the infrastructure for fleet use of non-petroleum fuels, and maximize the use of alternative fuels in fleet vehicles designed to operate on them.
6. Initiate and support a vehicle efficiency education program that includes driving and maintenance practices, repowering options, and new vehicle technologies.

7. Work with California port authorities to accommodate the need for petroleum importing infrastructure in port-related strategic planning processes, including the need for cleaner diesel and the port infrastructure to support it.
8. Ensure that permitting of petroleum infrastructure is expeditious and environmentally-sound.
9. Establish a strategic planning process with local governments and regional planning organizations to identify opportunities to reduce transportation energy consumption through improved public transit and land use planning.
10. Pursue policies that simultaneously achieve reductions in petroleum fuel use as well as criteria pollutant and greenhouse gas emissions whenever possible.
11. Undertake a biennial review of the California Hydrogen Highway Network effort and the state of hydrogen technologies.
12. Initiate and lead an outreach plan to inform the public of the benefits and objectives of the California Hydrogen Highway Network.
13. Complete the first 100 hydrogen stations in the State on a 50/50 funding match basis with the private sector.

## 8. Research, Development and Demonstration

California's continued success in supplying an efficient and diverse mix of resources to meet our energy needs is dependent upon technological innovations. The agencies are committed to encouraging research, development, and demonstration (RD&D) projects in technologies that will allow California to achieve its policies to make energy efficiency, demand response and renewable resources both more effective and cost-competitive. We must also encourage RD&D for conventional generation sources and transportation fuels to reduce emissions, increase efficiency, and mitigate environmental impacts.

### KEY ACTIONS

1. Transform RD&D projects on energy efficiency technologies into future energy efficiency tools and standards to ensure continuing technology improvements.
2. Prioritize and allocate RD&D funding for energy efficiency and demand response, including new communication and control technologies, planning models, end-use technologies, and validation methodologies.
3. Align RD&D funding with public policy goals for new renewable technologies and greenhouse gas mitigation technologies, including efficiency and renewable generation technologies, as well as transportation sector fuel and efficiency improvements.
4. Align public purpose funded natural gas RD&D to reflect supply policies affecting biogas, syngas, and improved long-term storage reservoir management, safety and efficiency.
5. Support RD&D to improve the efficiency of light-, medium-, and heavy-duty gasoline and diesel vehicles; to reduce the cost of producing, distributing and dispensing non-petroleum fuels; to use biomass waste material in producing

transportation fuels; to improve state-of-the-art vehicle technologies; and to capitalize on the synergies of mobile and stationary applications.

6. Support coal technology research and development, and continue to develop methods for capturing and storing significant amounts of $CO_2$, either as an integral part of the energy conversion process or in pairing with external $CO_2$ sequestration.
7. Support the development of cost-effective dry-cooling technologies and reduce once-through cooling practices to minimize the impact of new generation on California's water resources.

## 9. Climate Change

Governor Schwarzenegger signed Executive Order S-3-05 on June 1, 2005, clearly establishing California's leadership in and commitment to the fight against climate change. The Executive Order establishes greenhouse gas (GHG) emission reduction targets that call for a reduction of GHG emissions to 2000 levels by 2010; to 1990 levels by 2020; and to 80 percent below 1990 levels by 2050. The Executive Order also directs Cal-EPA to lead a multi-agency effort to conduct an analysis of the impacts of climate change on California and to develop strategies to achieve the targets and mitigation and adaptation plans for the State.

State agency programs that reduce or avoid greenhouse gas emissions will be critical to meeting the Governor's policy goals. Cal-EPA has convened a Climate Action Team that is responsible for meeting those goals and is comprised of high-level representatives from the Business, Transportation and Housing Agency, the Cal-EPA, the CPUC, the CEC, the Department of Food and Agriculture and the Resources Agency. Cal-EPA has also established a subgroup of the Climate Action Team specifically to evaluate options for a statewide "cap and trade" program.

Climate change is the most serious threat to our environmental future, and demands immediate action. Its symptoms are already evident in California. The transportation sector is the primary contributor to our greenhouse gas emissions, and key emissions reductions in this sector will be accomplished by implementing the motor vehicle greenhouse gas emission regulations established by the Air Resources Board pursuant to 2002 legislation (AB 1493, Pavley). Increasing energy efficiency, demand response, and renewable resources to the maximum extent possible in California and the western region will further reduce our contribution to climate change. Due to the strong connection between energy use and climate change, many necessary actions to reduce greenhouse gas emissions have already been outlined in previous sections.

### KEY ACTIONS:

1. Implement the motor vehicle greenhouse gas regulations.
2. Implement all strategies identified by the Climate Action Team as needed to meet the Governor's GHG emission reduction goals.
3. Report to the Governor and the Legislature in January 2006, and every other year following to provide regular updates on the progress made toward meeting the Governor's target and other directives in Executive Order S-3-05.

4. Report to the Governor on the findings of the Climate Action Team subgroup on cap and trade options for the State.
5. Consider 2010, 2020, and 2050 GHG reduction targets for retail sellers to contribute to meeting the Governor's GHG emission reduction targets.
6. Coordinate with the Climate Action Team on the regulatory proceeding that is considering establishment of a cap and trade program for IOUs.
7. Ensure that energy supplies serving California, from any source, are consistent with the Governor's climate change goals.
8. Participate in public outreach efforts to educate the public and businesses in California on climate change impacts and actions to mitigate emissions.
9. Encourage all participants in the electricity, natural gas, and transportation fuels industries, as well as other regulated industries, to participate in the California Climate Action Registry and to improve reporting of GHG emissions.
10. Identify western state policies and strategies to achieve production of 30,000 MW of clean energy across the west by 2015, consistent with the Western Governors' Association Clean and Diversified Energy Advisory Committee and West Coast Climate Initiative goals.[5,6]
11. Identify methodologies to quantify the expected costs and benefits of climate change policies.

[5] See WGA Policy Resolution 04-14, June 22, 2004, at <http://www.westgov.org/wga/policy/04/clean-energy.pdf>.
[6] See WGA's Clean and Diversified Energy Initiative webpage at <http://www.westgov.org/wga/initiatives/cdeac/index.htm>. Also see <http://www.climatechange.ca.gov/westcoast/index.html> for information on the West Coast Governors' Initiative.

# APPENDIX A

## *EAP I Progress Report*

Since 2003, California has worked diligently to implement EAP I, which contained both overall policy objectives for the State's energy sector while also proposing a series of specific action items for the agencies to undertake. While we have been successful in accomplishing many of the action items we proposed in EAP I, we recognize that much more work remains to be done in California to ensure a reliable, affordable and environmentally-sound energy industry. A complete assessment of our response to the specific actions items prescribed in EAP I is provided below.

## *I. Optimize Energy Conservation and Resource Efficiency*

1. **Implement a voluntary dynamic pricing system to reduce peak demand by as much as 1,500 to 2,000 megawatts by 2007.**

   **Status: In Progress**

   - The CPUC authorized voluntary demand response programs for large customers, with statewide potential estimated at 520 MW, and a statewide two-year pilot program to study the demand response capability of residential and small commercial customers.
   - The CEC provided funding to install 23,300 interval meters on large customers starting in 2001, and the CPUC directed the IOUs to complete the process and authorized funding when general funds were exhausted.
   - Pursuant to CPUC directions, the IOUs have submitted plans to deploy advanced metering infrastructure (AMI) systems for all customers for consideration in 2005 and 2006.

2. **Improve new and remodeled building efficiency by 5 percent.**

   **Status: Achieved**

   - The CEC adopted building energy efficiency standards for existing and new buildings, effective October 2005, and adopted appliance standards effective mid-April 2005, and subsequent years.
   - The CPUC and the CEC approved programs to provide building tune-ups and retro-fits, and to install and to retrofit efficient lighting and HVAC systems.

3. **Improve air conditioner efficiency by 10 percent above federally mandated standards.**

   **Status: Achieved**

   - The CEC supported the Attorney General's successful multi-state lawsuit against the Federal Department of Energy's rollback of air conditioner standards, allowing California to implement the ten percent higher standards.

- The CPUC approved programs to install energy efficient air conditioners, to improve ventilation, and to promote upgrades and enhancements in codes and standards.

4. **Make every new state building a model of energy efficiency.**

   **Status: In Progress**

   - The CPUC ordered IOUs to emphasize commercial and state building efficiency programs in their 2006-2008 program cycle as a step in implementing the Governor's Green Building Action Plan.
   - The CEC is developing a benchmarking methodology that would apply to all commercial buildings in California. The CEC is scheduled to submit the proposed methodology and implementation schedule to the Governor in July 2005.

5. **Create customer incentives for aggressive energy demand reduction.**

   **Status: In progress**

   - The CPUC established demand response and interruptible programs that provide customer incentives through bill credits or discounted rates, with 1,590 MWs of interruptible load available.
   - The CPUC established free energy audit services to help customers evaluate their demand response capability.
   - The CPUC authorized programs for IOUs and 3rd parties to offer rebates for energy efficient products such as lighting, fixtures, windows, coolers, HVAC and refrigeration systems, programmable thermostats, pool pumps and motor replacements.

6. **Increase local government conservation and energy efficiency programs.**

   **Status: Achieved**

   - The CPUC approved $49 million of partnership programs for local governments and schools to provide energy efficiency incentives, services, and education for customers in 2004 and 2005.
   - The CEC completed two bond issuances totaling $66 million to finance energy efficiency projects for local governments and schools.

7. **Incorporate, as appropriate per Public Resources Code section 25402, distributed generation or renewable technologies into energy efficiency standards for new building construction.**

   **Status: In Progress**

   - The CEC is investigating how solar generation can be included in the 2008 Building Energy Efficiency Standards.

## *II. Accelerate the State's Goal for Renewable Generation*

1. **Add a net annual average of up to 600 MW of new renewable resources to the IOU's portfolios.**

   **Status: In Progress**

   - IOU contracts filed in 2005 add between 285-586 MW[1] of new renewable generation, with contracts in negotiation for 2005 and 2006 pushing the total well over 600 MW.
   - The 2002 and 2003 interim renewable solicitations resulted in over 620 MW in contracted capacity from existing renewable generation facilities.

2. **Establish key RPS implementation rules for IOUs by June 30, 2003.**

   **Status: Achieved**

   - The CPUC issued a decision on June 2003, that laid the foundation for the RPS program, and issued four additional decisions by July 2004, that set standard contract terms and conditions, established a benchmark price for contracts, created a methodology for calculating transmission costs, and developed an evaluation methodology for ranking RPS bids.

3. **Facilitate an orderly and cost-effective expansion of the transmission system to connect potential renewable resources to load.**

   **Status: In Progress**

   - In conjunction with the CEC's report on the location of renewable resource potential in California, the CPUC prepared a comprehensive transmission plan for conceptual facilities for wind, solar, geothermal and biomass renewable electricity generation.
   - Pursuant to CPUC order, SCE filed an application to build transmission to the Tehachapi region in anticipation of tapping 4,000 MW of wind resource potential. The CPUC is now processing the request.
   - The CPUC and the CEC established working groups to facilitate transmission projects to access renewable resources in the Tehachapi and Imperial Valley areas.

4. **Initiate the development of RPS compliance rules for energy service providers and community choice aggregators.**

   **Status: Achieved**

   - The CPUC held legal briefing and evidentiary hearings regarding ESP and CCA participation in the RPS, and posted a draft framework decision in June 2005.

[1] Some contracts allow the generators to increase output in an incremental fashion. Final output is determined by how many units are brought on line per contract.

5. **Coordinate implementation with all relevant state agencies and with municipal utilities to facilitate their achievement of the standard.**

   **Status: In Progress**

   - The CEC, CPUC, CPA and CAISO initiated a statewide renewables forum in 2004 and have held three coordination meetings.
   - The CEC provides assistance to municipal utilities on an ad hoc basis and is tracking their progress towards meeting the EAP goals for renewables.

6. **Encourage companies that invest in energy conservation and resource efficiency to register with the state's Climate Change Registry.**

   **Status: Achieved**

   - The CEC and CPUC joined the Registry in order to lead by example.
   - In conjunction with other state agencies, the CPUC held an en banc in February 2005, to explore climate change issues and sent letters to CPUC-regulated entities encouraging them to join the Registry.
   - The CPUC issued a decision in April 2005, directing the IOUs to include marketing and outreach activities to support the Registry in their energy efficiency program plan applications.
   - The CEC provides technical assistance to the Registry on its reporting and certification protocols.

## *III. Ensure Reliable, Affordable Electricity Generation*

1. **Add new generation resources to meet anticipated demand growth, modernize old, inefficient and dirty plants and achieve and maintain reserve levels in the 15 percent-18 percent range. Current estimates show a statewide need for 1500 – 2000 MW per year.**

   **Status: In Progress**

   - Since the EAP was adopted in March 2003, the CEC permitted 8,345 MW of new power plants, 6,730 MW of new and re-powered plants became operational, and 1,380 MW more will be online by the end of July 2005.
   - In January and October 2004, the CPUC adopted resource adequacy requirements for the IOUs and ESPs to secure a 15-17 percent reserve margin by June 2006.

2. **Finance a few critical power plants that the agencies conclude are necessary and would not otherwise be built. An estimated 300 MW of peaking capacity located in critical areas is needed to provide local reliability, help achieve adequate reserves, and reduce congestion and the need for new transmission lines.**

   **Status: Achieved**

   - Through the CPUC's procurement process, 500 MW of previously mothballed generation has returned to service in Southern California under IOU contracts.

- Significant new generation is now under construction after timely contract and permit review and approval by the CPUC and CEC, respectively, including Mountainview (1,050 MW), Palomar (550 MW), and Otay Mesa (570 MW).

3. **Work with the CAISO to ensure the development of a workable, competitive wholesale energy market that has meaningful market power mitigation rules.**

   **Status: In Progress**

   - State agencies participate in the CAISO's Market Redesign and Technology Upgrade (MRTU) process scheduled to be implemented in February 2007, and have supported at FERC the CAISO's development of a new market model based on locational marginal pricing (energy pricing that incorporates the cost of transmission congestion) and which includes extensive market power mitigation.

4. **Monitor the electricity market to identify any exercise of market power and manipulation, and work to improve FERC-established market rules to correct any observed abuses.**

   **Status: Ongoing**

   - State agencies participate in FERC proceedings, the CAISO Market Surveillance Committee, Seams Steering Group, and the Western Interconnection Market Monitoring Group to ensure adequate monitoring of electricity markets and to identify abuses of market power.

## *IV. Upgrade and Expand the Electricity Transmission and Distribution Infrastructure*

1. **The agencies will collaborate, in partnership with other state, local, and non-governmental agencies with energy responsibilities, in the California Energy Commission's integrated energy planning process to determine the statewide need for particular bulk transmission projects. This collaboration will build upon the California Independent System Operator's annual transmission plan and evaluate transmission, generation and demand side alternatives. It is intended to ensure that state objectives are evaluated and balanced in determining transmission investments that best meet the needs of California electricity users.**

   **Status: Ongoing**

   - The CPUC granted regulatory approval for construction of additional transmission on Path 15, the major interconnection between northern and southern California, and approved several other major transmission upgrades, including Miguel-Mission and Otay Mesa in San Diego and Jefferson-Martin on the San Francisco Peninsula.
   - State agencies collaborated on the CEC's 2003–2004 IEPR energy planning processes, which provided policies to improve the transmission planning and permitting processes.

- State agencies are collaborating in the 2005 IEPR process to prepare a strategic transmission grid plan for the State with recommendations for transmission infrastructure investments.
- The CPUC and the CEC participate in the CAISO's annual transmission planning process of quarterly stakeholder meetings where projects are studied for one, five and ten year horizons, as proposed by PG&E, SCE, SDG&E, or by the CAISO.

2. **The Public Utilities Commission will issue an Order Instituting Rulemaking to propose changes to its Certificate of Public Convenience and Necessity process, required under Public Utilities Code § 1001 et seq., in recognition of industry, marketplace, and legislative changes, like the creation of the CAISO and the directives of SB 1389. The Rulemaking will, among other things, propose to use the results of the Energy Commission's collaborative transmission assessment process to guide and fund IOU-sponsored transmission expansion or upgrade projects without having the PUC revisit questions of need for individual projects in certifying transmission improvements.**

   **Status: In Progress**

   - The CPUC opened this rulemaking in January 2004, but the methodology to coordinate need determination between agencies remains under development in CAISO and CPUC forums.

3. **The Public Utilities Commission will ensure that IOUs build out and properly staff and maintain distribution systems to meet California's growth, provide reliable service, and stand ready to restore service after unplanned distribution system outages.**

   **Status: In Progress**

   - The CPUC authorized the IOUs in their recent general rate cases to increase spending by four to seven percent on capital additions for distribution infrastructure over the next three years, with an emphasis on improving reliability.

4. **The Energy Commission will work with municipal utilities to help ensure completion of transmission expansion or upgrade projects in their systems for which the collaborative transmission assessment process finds a need.**

   **Status: In Progress**

   - The CEC is assessing municipal utilities' transmission expansion plans and will recommend actions on near-term transmission projects (including municipal utility projects) in its November 2005 Strategic Transmission Investment Plan.

## *V. Promote Customer and Utility Owned Distributed Generation*

1. **Promote clean, small generation resources located at load centers.**

   **Status: Achieved**

- The CPUC adopted favorable rate policies for DG, including exemptions from stand-by and departing load charges, and expanded net metering.
- State incentive programs paid rebates leading to 116 MW of renewable and clean DG from the CPUC's Self Generation Incentive Program and 53 MW of primarily solar from the CEC's Emerging Renewables Program.
- The CPUC and the CEC streamlined interconnection rules, resulting in 487 MW of interconnected DG since January 2001, and resulting in an 80 percent reduction in the time to interconnect new distributed generation.

2. **Determine whether and how to hold distributed generation customers responsible for costs associated with Department of Water Resources power purchases.**

   **Status: Achieved**

   - The CPUC adopted a DG cost responsibility surcharge in April 2003, and provided exemptions for a capped amount of clean and large-scale DG, which the CEC manages, monitors, and publicly reports.

3. **Determine system benefits of distributed generation and related costs.**

   **Status: In Progress**

   - The CEC Public Interest Energy Research Program has invested over $19 million to quantify the system benefits and effects of interconnecting DG to the electric grid.
   - The CPUC and the CEC are developing a common DG cost-benefit methodology for utility procurement and planning processes, and for setting incentive levels for renewable and clean DG, with evidentiary hearings held in May 2005, and a decision expected by the end of 2005.

4. **Develop standards so that renewable distributed generation may participate in the Renewable Portfolio Standard program.**

   **Status: Achieved**

   - The CPUC determined that the owner of renewable DG facilities owns the renewable energy credits associated with the generation of electricity from those facilities and is eligible to participate in the RPS program.

5. **Standardize definitions of eligible distributed generation technologies across agencies to better leverage programs and activities that encourage distributed generation.**

   **Status: In Progress**

   - The CEC developed a working definition in the 2005 IEPR-related proceedings and the CPUC is developing a formal definition through evidentiary hearings, with a decision expected by the end of 2005.

6. **Collaborate with the Air Resources Board, Cal-EPA and representatives of local air quality districts to achieve better integration of energy and air quality policies and regulations affecting distributed generation.**

   **Status: In Progress**

   - The agencies are participating in the Cal-EPA process to implement a 2007 DG Emission Standard.

7. **The agencies will work together to further develop distributed generation policies, target research and development, track the market adoption of distributed generation technologies, identify cumulative energy system impacts and examine issues associated with new technologies and their use.**

   **Status: In Progress**

   - EAP I formalized a long-standing CPUC/CEC Distributed Generation Collaborative.
   - The CEC completed a comprehensive set of recommendations to revise California's interconnection rules, and submitted them to the CPUC for public comment in February 2005. The CPUC expects to issue a decision on the recommendations in the third quarter of 2005.

***VI. Ensure Reliable Supply of Reasonably Priced Natural Gas***

1. **Identify critical new gas transmission, distribution and storage facilities needed to meet California's future needs.**

   **Status: Achieved**

   - The CEC initiated its 2005 Integrated Energy Policy Report, which includes an assessment of long-term natural gas infrastructure needs.
   - The CPUC adopted flexible capacity contract approval procedures, and approved natural gas distribution pipeline requirements for the Southern California Gas Company, San Diego Gas and Electric Company, Pacific Gas and Electric Company, and Southwest Gas.
   - Over 1,000 MMcfd of interstate pipeline capacity to California has been added, mainly due to Kern River expansion in May 2003.
   - Over 20 Bcf of storage capacity has been added since early 2002, and more capacity is expected in the next few years.
   - The CPUC and the CEC established a natural gas research and development program to facilitate more efficient use of natural gas.

2. **Monitor the gas market to identify any exercise of market power and manipulation, and work to improve FERC-established market rules to correct any observed abuses.**

   **Status: In Progress**

   - The CPUC and CEC have joined FERC investigations of price rises in early 2003, and early 2004, conduct monthly meetings to monitor

infrastructure and market conditions, and prepare monthly reports summarizing California's natural gas infrastructure and operations.

- Agencies' efforts contributed to the FERC conclusion of the El Paso market manipulation case, resulting in customer refunds of hundreds of millions of dollars.

**3. Evaluate the net benefits of increasing the state's natural gas supply options, such as liquefied natural gas (LNG).**

**Status: In Progress**

- The CPUC adopted policy rules in September 2004, that establish a level playing field for consideration of new natural gas supplies from LNG, and adopted procedures by which natural gas utilities would obtain new contracts with LNG suppliers.
- The CEC prepared a report in early 2005 of existing safety rules and regulations governing LNG terminals, and updated its long-term outlook on natural gas demand and supplies available to California.
- The CEC chairs monthly meetings of the LNG Interagency Working Group to ensure a smooth flow of information from all perspectives on LNG issues affecting California.

**4. Support electric utilities and gas distribution companies entering into longer-term contracts as a hedge against volatile and high spot market prices.**

**Status: In Progress**

- The CPUC has not taken specific actions to encourage additional long-term physical natural gas supply contracts as a policy and instead has encouraged natural gas and electric utilities to use financial instruments and storage to hedge against volatile spot market natural gas prices in order to meet this policy objective.

# FUNDING AND SAVINGS FOR ENERGY EFFICIENCY PROGRAMS FOR PROGRAM YEARS 2000 THROUGH 2004

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In support of the
*2005 Integrated Energy Policy Report*

**STAFF PAPER**

**DISCLAIMER**

This document was prepared by the staff of the California Energy Commission for public review and consideration. The conclusions and recommendations are based on information reviewed by staff and represent staff's best professional judgment, but do not necessarily represent the views of the Energy Commission. The Energy Commission has not approved or disapproved this report, nor has the Commission assessed the accuracy or adequacy of the report's information.

JULY 2005
CEC-400-2005-042

# FUNDING AND SAVINGS FOR ENERGY EFFICIENCY PROGRAMS FOR PROGRAM YEARS 2000 THROUGH 2004

This paper is a brief summary of the energy efficiency programs administered by the major investor-owned utilities (IOUs) in California: Pacific Gas and Electric (PG&E), Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E) over the last five years. The purpose of this paper is to highlight recent trends regarding energy efficiency funding, savings, and cost-effectiveness of these programs.

The data used in this paper was compiled from the annual reports on energy efficiency filed by each IOU with the California Public Utilities Commission (CPUC). This paper tracks energy efficiency efforts for the program years 2000 through 2004. All dollar amounts are reported in nominal dollars.

## Annual Spending for Energy Efficiency Programs

**Figure 1**
**Annual Spending for Energy Efficiency Programs**
**($1.4 billion was spent for PY 2000-2004 with an average of $286 million per year)**

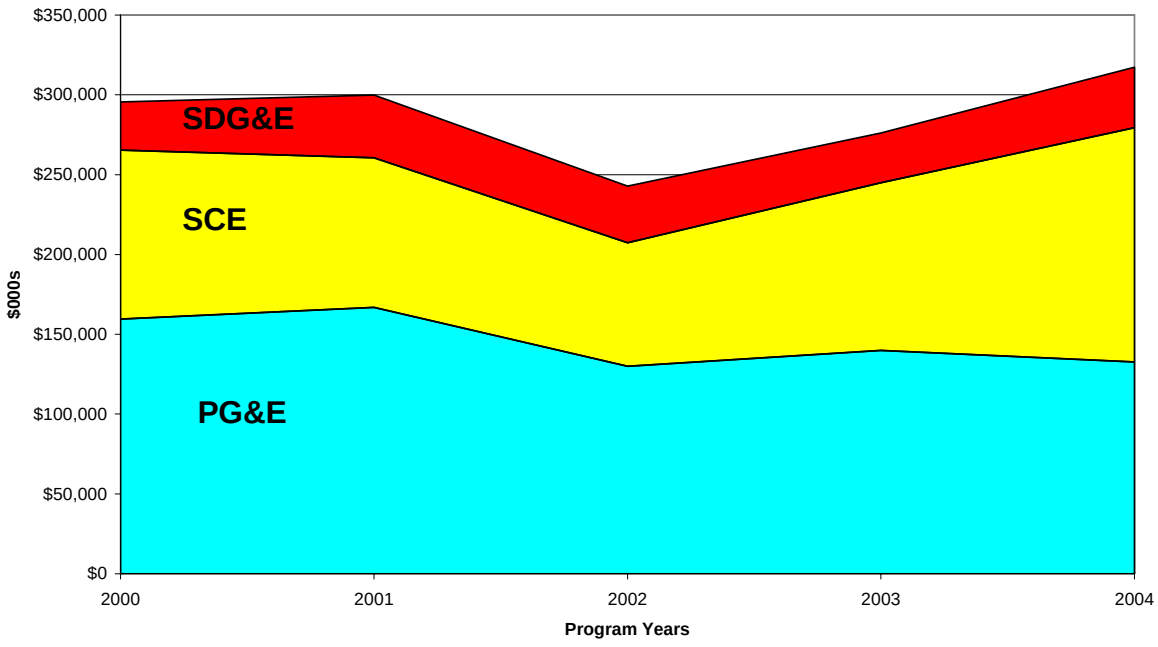



Figure 1 - Collectively, the three IOUs expended $1.4 billion on energy efficiency programs for the program years 2000 through 2004. For the years 2000 and 2001, the three IOUs expended close to $300 million each year. In 2002, the spending fell to $243 million. Spending increased in 2003 to $276 million and increased again in 2004 to a high of $317 million.

## Annual Spending by Sector

**Figure 2**
**Cumulative Spending by Sector for PG&E, SCE and SDG&E for Program Years 2000-2004**
**($1.4 billion was spent for PY 2000-2004 with an average of $286 million per year)**

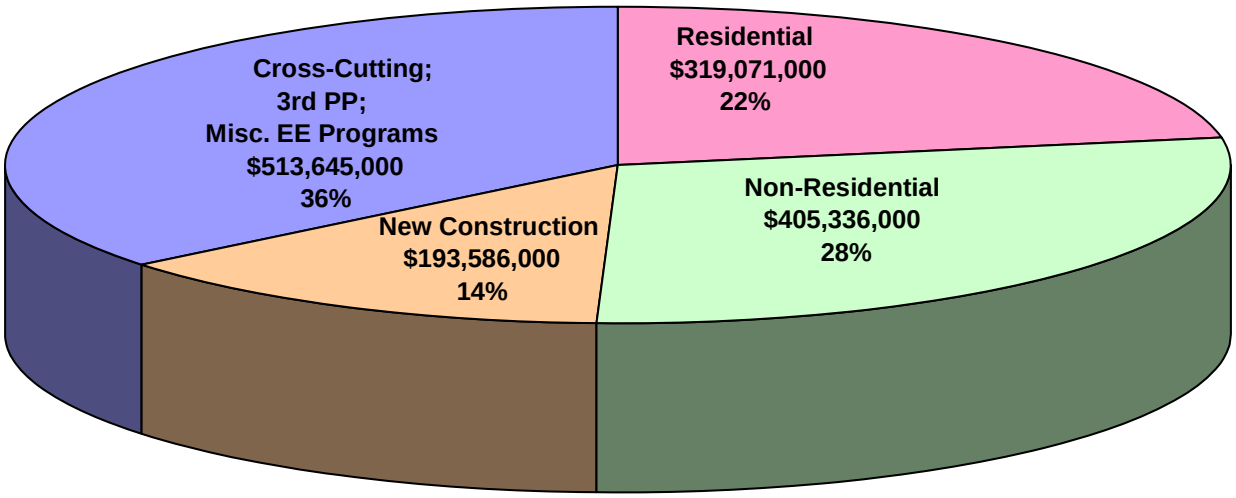



Figure 2 – Of the $1.4 billion that the three IOUs expended on energy efficiency programs for the program years 2000 through 2004, 14 percent was spent on new construction programs; 22 percent was spent on residential programs; 28 percent was spent on non-residential programs; and 36 percent was spent on cross-cutting, third party programs, and miscellaneous energy efficiency programs.

The term cross-cutting is used for energy efficiency programs that involve any or all of the following: multiple customer types (residential and/or non-residential), and/or multiple building types (retrofit, remodeling, and/or new construction). All of these programs are designed to support and drive energy efficiency and energy savings. Some examples of cross-cutting programs include information and education, marketing and outreach, codes and standards advocacy, and emerging technology.

**Figure 3**
**Spending by Sector for PG&E, SCE and SDG&E for Program Years 2000-2004**
**($1.4 billion was spent for PY 2000-2004 with an average of $286 million per year)**

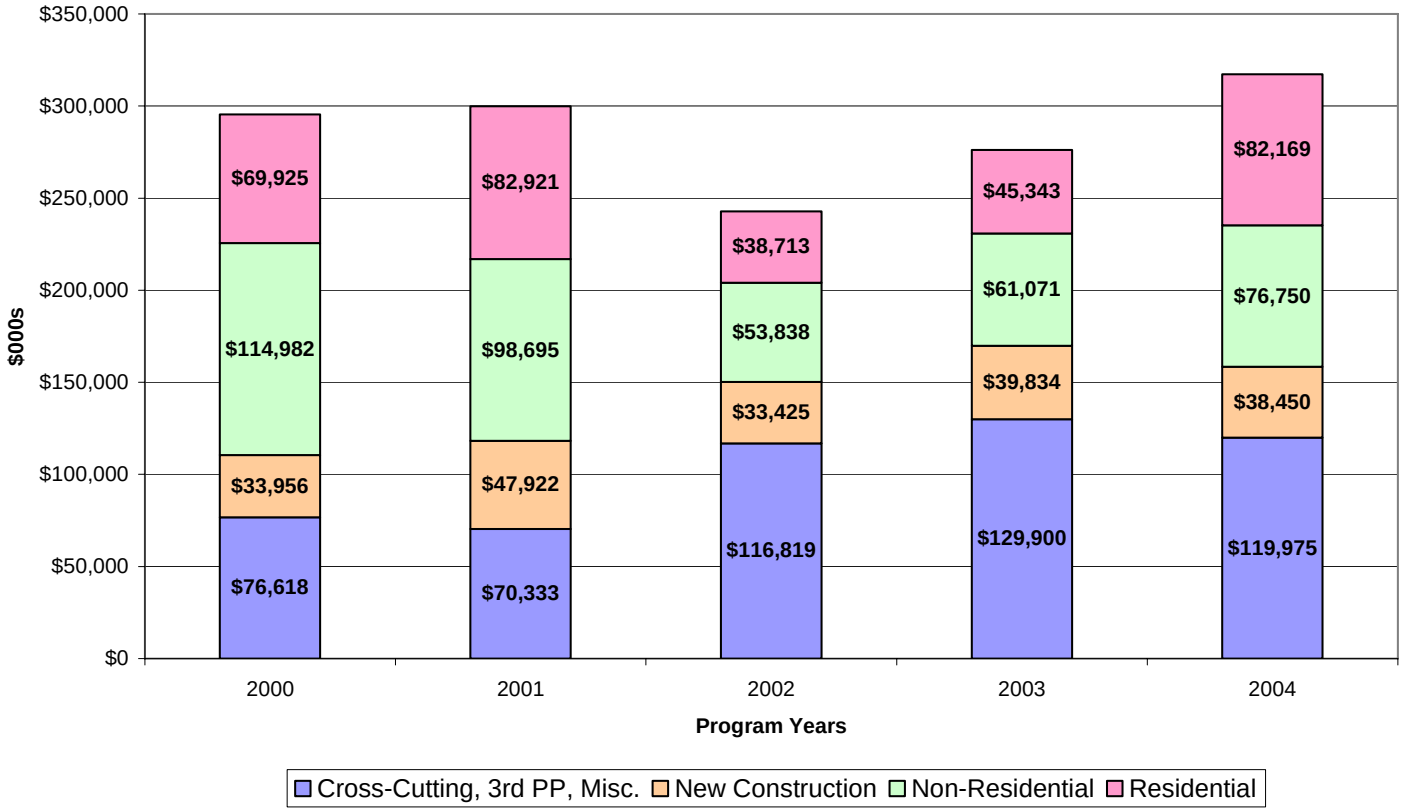



Figure 3 – This graph shows the breakdown by year of the spending for the three different customer sectors and a combination category. This combination category includes cross-cutting utility programs that have multiple customer sectors as well as programs that are administered by third parties. For years 2000 through 2004, these third-party programs accounted for nearly $50 million dollars of the combination category budget.

Except for years 2000 and 2001, the spending has been highest in the combination category. Spending on non-residential programs energy efficiency programs was highest in 2000 and 2001, and the second highest amount of money for years 2002 and 2003. The non-residential energy efficiency programs include both industrial and commercial customers. Spending for residential programs has been the most volatile; spending in this sector has ranged from $38.7 million in 2002 to nearly $83 million in 2003. For all five years, new construction programs have spent the least amount of money.

# Spending by Individual Utility

**Figure 4**
**Annual Spending for Energy Efficiency Programs by PG&E, SCE and SDG&E for PY 2000-2004**
**($1.4 billion was spent for PY 2000-2004 with an average of $286 million per year)**

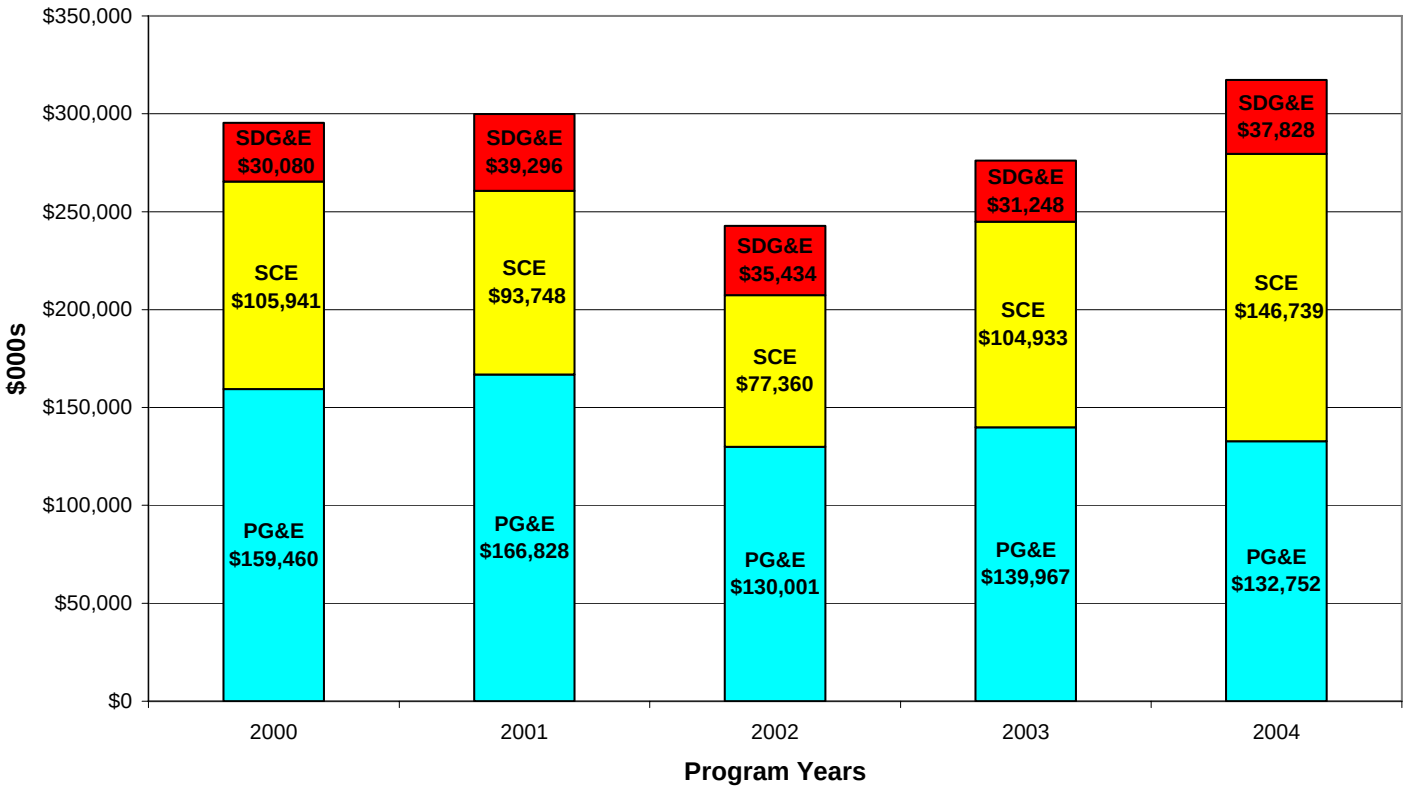



Figure 4 – This graph shows what each IUO spent on energy efficiency programs for each program year. Spending from PG&E was the highest of all the utilities for all years except 2004. In 2000, PG&E spent 88 percent of its energy efficiency budget. In the year 2001, PG&E's actual spending exceeded its budget for energy efficiency programs. In 2002, 2003 and 2004, PG&E spent 91 percent, 92 percent, and 90 percent respectively of its budget for energy efficiency programs. In the years 2000 and 2004, SCE spent 99 percent and 98 percent respectively of its energy efficiency budget. For the years 2001 and 2003, SCE spent 93 percent and 87 percent respectively of its budgeted funds. For program year 2002, SCE only spent 64 percent of its budget on energy efficiency programs. SDG&E spent less than 77 percent of its budgeted funds on energy efficiency programs for program years 2000, 2002, and 2004. In 2001 and 2003, SDG&E spent 90 percent and over 100 percent respectively of its budgeted funds.

## First Year Savings in Gigawatt Hours

**Figure 5**
**First Year Savings (GWh/yr) by Utility Energy Efficiency Programs**

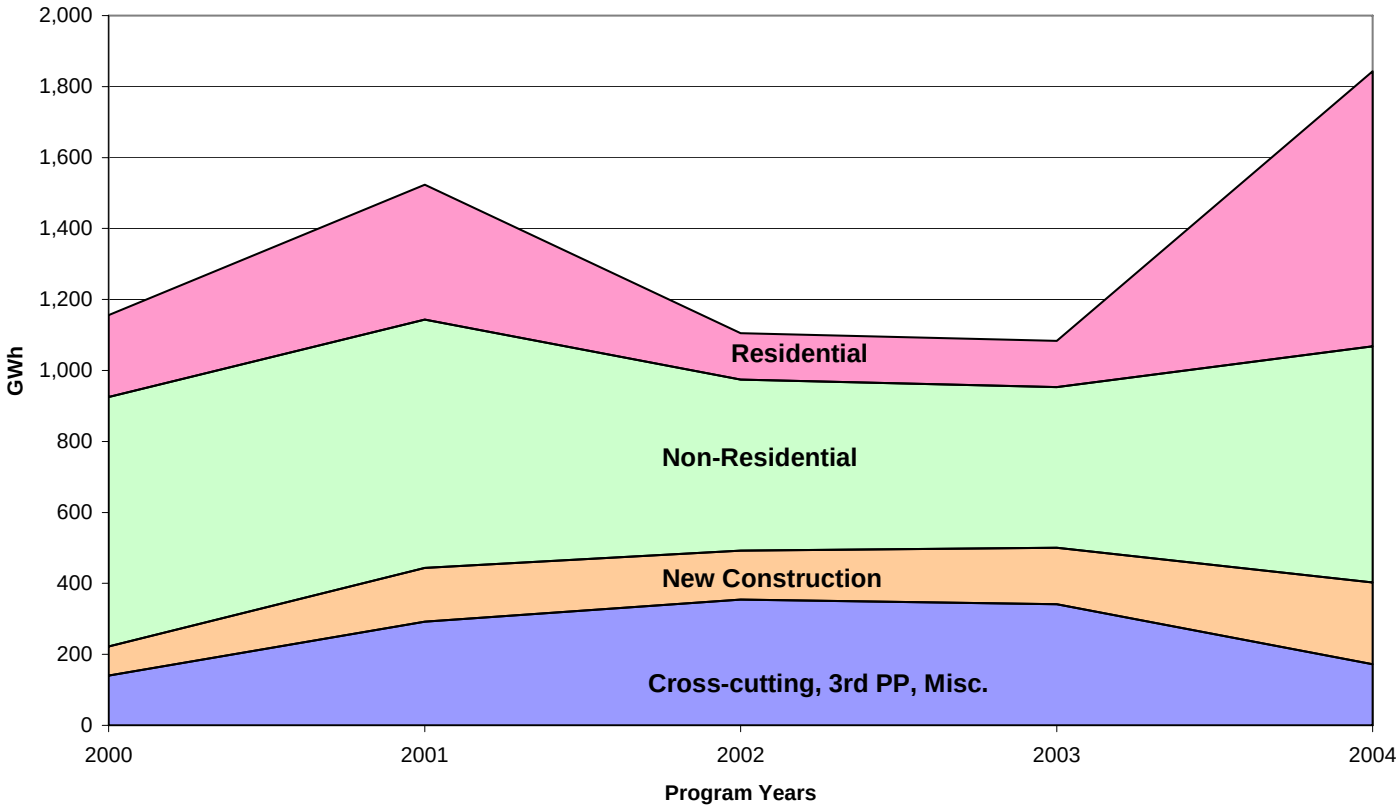



Figure 5 – This graph shows the first year savings in Gigawatt hours from the previously identified sectors. The year 2004 had the greatest first year savings with 1,843 Gigawatt hours saved. Program Year 2003 had the least first year savings with only 1,084 Gigawatt hours saved. For all program years except for the year 2004, non-residential energy efficiency programs had the greatest first year savings in Gigawatt hours. The year 2004 had the greatest first year savings in the residential energy efficiency programs. It appears that this major upswing in savings was caused by a significant increase in lighting savings from the residential sector that has yet to be verified.

# First Year Peak Savings in Megawatts

**Figure 6**
**First Year Peak Savings of Utility Energy Efficiency Programs**

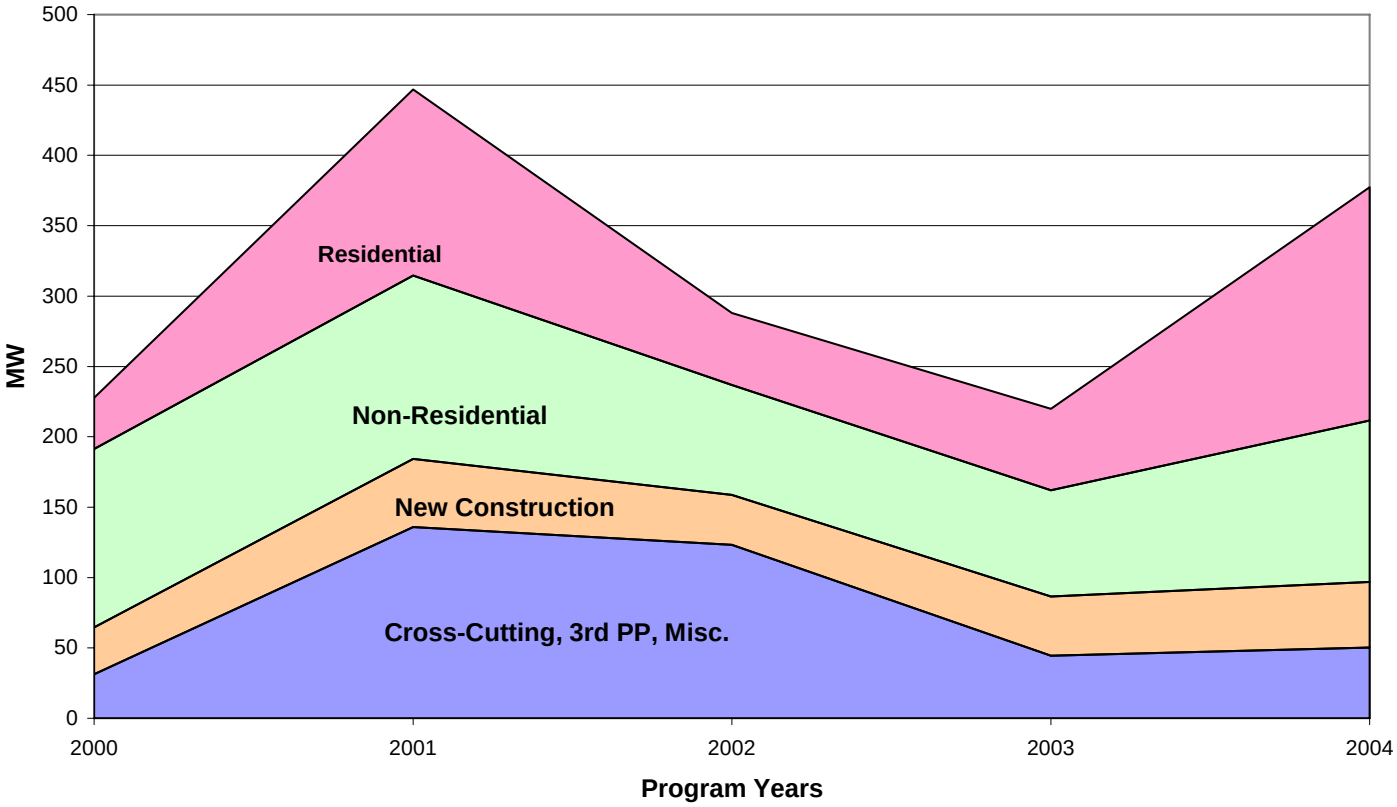



Figure 6 – Shows the first year peak savings in megawatts. The year 2001 had the greatest first year peak savings with 447 megawatts saved. The year 2004 was close behind in savings with 377 megawatts saved. For program years 2000 and 2003, non-residential programs had the greatest first year peak savings. The cross-cutting and third party programs had the greatest megawatts savings for years 2001 and 2002. The year 2004 had the greatest first year peak savings in the residential energy efficiency programs with 166 megawatts saved.

## Cost Effectiveness

**Figure 7**
**Summary of Cost Effectiveness by Sector for PG&E, SCE and SDG&E for Program Years 2000-2004**

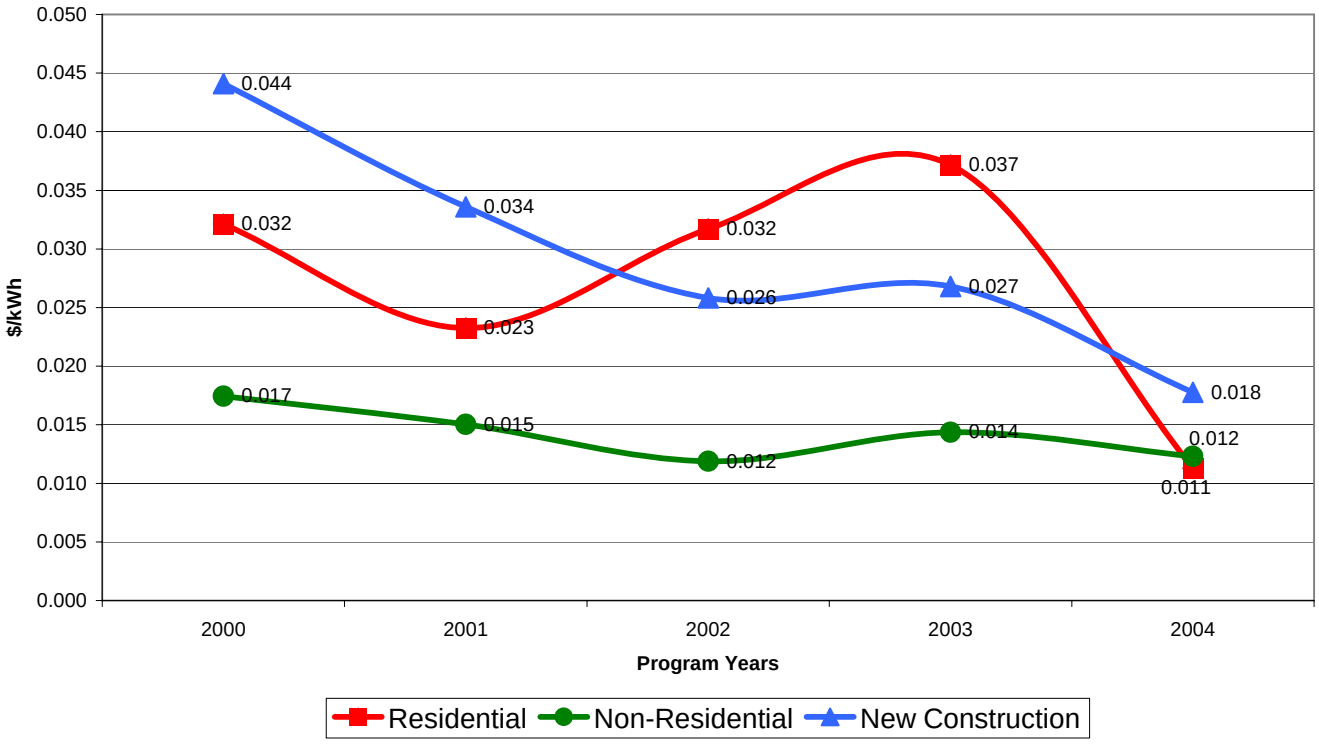



Figure 7 – This graph shows a summary of the reported program cost effectiveness by sector for the aggregated IOUs for program years 2000 through 2004. We used levelized costs (in $/kWh) as the indicator of cost effectiveness, but information on benefit cost ratios is also available. We chose this method because research has shown that policy makers have an easier time comparing levelized costs for demand versus supply sources than comparing benefit cost ratios which are often not provided for supply options.

Over the past five years, program effectiveness has increased in all the sectors. For the year 2004, all sectors were at a levelized cost of a little over 1.1 cents per kWh. New construction had the greatest decrease in levelized cost over the five years. In 2000, the new construction energy efficiency programs were at a levelized cost of 4.4 cents per kWh. By the year 2004, the costs for these programs were now at 1.8 cents per kWh. The non-residential programs were the most stable for the 2000 through 2004 varying only slightly from a high of 1.7 cents per kWh in 2000 to 1.2 cents per kWh in 2004. The residential energy efficiency programs had the most variance of all three sectors. The year 2003 had a high of 3.7 cents per kWh and then dropped to the lowest point in the five years to 1.1 cents per kWh in 2004.

These calculations assume an average useful measure life of 12 years and a real discount rate of 4 percent per year. These savings calculations count only utility program costs and incentives and do not include the incremental costs of the measures. Adding these costs would increase the estimates of levelized costs here from 30 to 80 percent, depending on the fraction of the measure cost covered by utility incentives.

To calculate the levelized cost of conserved energy, we used the following formulas:

$$\text{Levelized Cost of Conserved Energy} = \frac{\text{Program Costs x CRF}}{\text{First year kWh saved}}$$

$$\text{Capital Recovery Factor (CRF)} = \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

$i$ = real discount rate
$n$ = useful life period

These calculations assume an average useful measure life of 12 years and a real discount rate of 4 percent per year.

**Figure 8**
**Comparison of EE Program Costs to Supply Generation Costs**

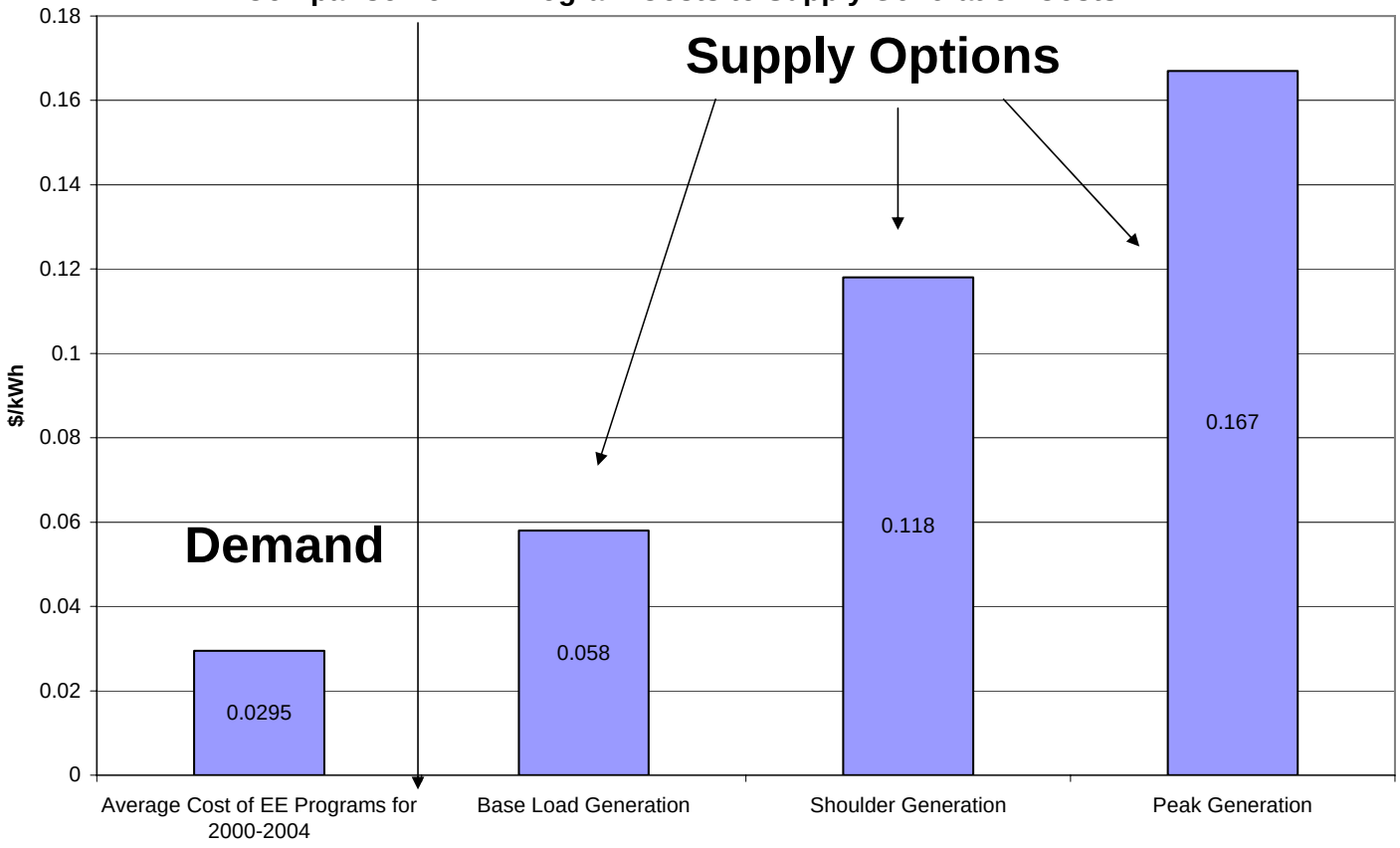



Figure 8 – This graph compares the levelized costs of the of the energy efficiency programs averaged for program years 2000 through 2004 to the costs of providing energy generation for specific load blocks. The average cost of the energy efficiency programs for program years 2000 through 2004 was 2.9 cents per kWh. As noted in the 2003 electricity goals report (*Proposed Energy Savings Goals for Energy Efficiency Programs in California*, California Energy Commission, October 27, 2003), the levelized cost for electricity generation during the Base Load was estimated at 5.8 cents per kWh, nearly double the cost of the averaged levelized cost for the energy efficiency programs. The levelized cost for electricity generation provided during the Shoulder time period is 11.8 cents per kWh, four times the cost of the averaged levelized cost for the energy efficiency programs. Finally, the levelized cost for the electricity generation for Peak time period is 16.7 cents per kWh, five and half times the cost of the averaged levelized cost for the energy efficiency programs for years 2000 through 2004. This graph shows that the average levelized costs for demand are still much less than the levelized costs for supply generation alternatives.

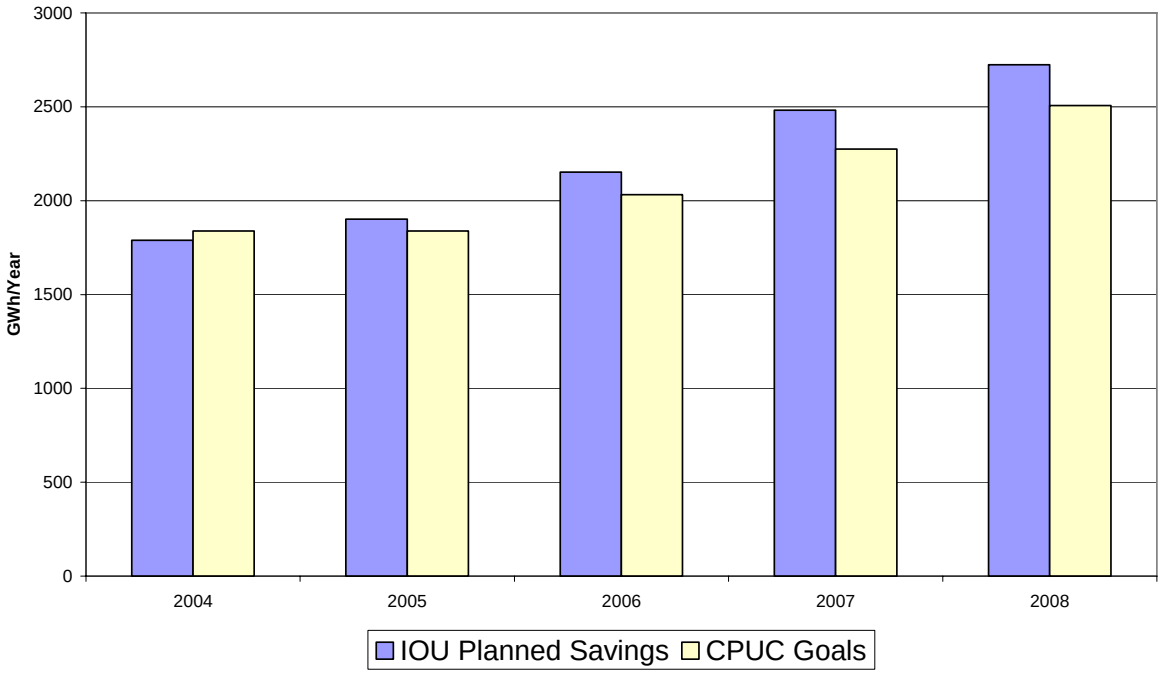
We use the following time periods to define base load, shoulder time period, and peak time period:

- Shoulder time period includes weekdays from 8 a.m. to 1 or 2 p.m. and from 7 p.m. to 9 p.m.
- Peak time period is between 12 p.m. and 7 p.m. on weekdays between the months of May and October.
- Base load is essentially all other time periods.

## 2006 through 2008 IOU Energy Efficiency Program Portfolios

California's investor-owned utilities submitted their portfolio plans to the CPUC on June 1, 2005. Initial assessments by the utilities' Peer Review Groups and the CPUC's consultants conclude that the total program portfolio "has a good chance" of meeting the near term goals for energy savings, peak demand reduction, and therm savings. Figure 9 shows the comparison of projected savings with goals for the IOUs. The 2004 through 2013 goals should achieve 90 percent of the remaining cost-effective potential that is reachable through aggressive program activity.

**Figure 9**
**IOU Projected Savings Compared to Goals 2004-2008**



Through procurement proceedings, ratepayer funds are once again available to fund energy efficiency beyond levels in the PGC. The IOUs have proposed large increases over their 2004-2005 budgets as a result. Table 1 shows the preliminary spending proposals and the relative sizes of the annual increases.

Although energy savings declined significantly following the 2000-2001 crisis, the trend today points toward significant increases in both spending and savings, consistent with the policies adopted in the *Energy Action Plan*.

**Table 1**
**Funding for 2006-2008 Programs ($000)**

| | 2006 | % Diff from Previous Year | 2007 | % Diff from Previous Year | 2008 | % Diff from Previous Year |
|---|---|---|---|---|---|---|
| PG&E | $240,000 | 83% | $281,000 | 17% | $345,000 | 23% |
| SCE | $243,000 | 43% | $243,000 | 0% | $243,000 | 0% |
| SDG&E | $81,000 | 107% | $91,000 | 12% | $106,000 | 16% |
| SCG | $48,000 | 47% | $61,000 | 27% | $73,000 | 20% |

The likelihood of meeting the longer-term goals, however, is less certain. Achieving the future goals will require a commitment to innovative programs, including new technologies and program strategies, continuous improvement in program designs, and investments in program approaches expected to yield significant savings in the outer years. Uncertainties that could affect the achievement of these goals include the following:

- The amount of future cost-effective potential could increase or decrease, depending on cost-effectiveness, standards, equipment saturation, and emerging technologies.
- Values for evaluation parameters (net-to-gross ratio, unit energy savings, etc.) may be revised.
- Ramping up funding to these levels may be difficult. Coupling large funding increases with unproven program ideas carries greater risk for successful program delivery.
- Emphasis on current year savings, as required by the new counting rules, could dampen interest in longer-term investments, such as new construction and standard performance contracting.
- Achieving the long-range goals will depend on the ability of the utilities to expand their reach to customers and increase both the level of

savings per customer and the probability that customers will sustain these savings and continue to make efficient decisions.

## Summary

This paper describes the latest trends in funding and savings for energy efficiency programs over the last five years. We believe this information provides the necessary background for discussion on how to improve energy efficiency portfolios in the future and the likelihood that future program efforts will meet the Commission's energy and peak goals.

Total expenditures for the different energy efficiency programs ranged from a low of $243 million in 2002 to a high of $317 million in 2004. This is still less than the high water mark for efficiency programs of roughly $400 million in 1994. The total amount spent during these five years, 2000 through 2004, was $1.4 billion. The majority of the money spent was on cross-cutting and third party programs. The non-residential sector, which includes industrial and commercial customers, spent the second highest amount of money. New construction received the least amount of the funding for energy efficiency programs.

Average energy and peak savings from programs have been steadily increasing over the five year period, even after the significant drop in savings experienced between 2001 and 2004. The levelized costs for the energy efficiency programs in all sectors reached a low of a little over 1.1 cents per kWh in 2004 and when compared to the supply generation costs, the energy efficiency programs proved to be very cost effective.

The investor-owned utilities are likely to achieve the goals over the near-term 2004 through 2008 period. This likelihood is less certain looking out to 2013, unless significant changes occur in program investments and approaches.

**Links**

California Energy Commission Homepage - http://www.energy.ca.gov/

California Energy Demand 2006-2016 Staff Energy Demand Forecast - http://www.energy.ca.gov/2005publications/CEC-400-2005-034/CEC-400-2005-034-SD.PDF

California Public Utilities Commission - http://www.cpuc.ca.gov/static/index.htm

Pacific Gas & Electric 2004 Annual Earnings Assessment Proceeding - https://www.pge.com/regulation/AnnEarnAssessProc2005/Testimony/PGE/2005-01-Fwd/AnnEarnAssessProc2005_Test_PGE_20050502-03-Vol-III.pdf

Southern California Edison 2000-2004 Energy Efficiency Annual Reports - http://www.sce.com/AboutSCE/Regulatory/eefilings/Annual_Reports/

San Diego Gas & Electric 2004 Energy Efficiency Programs Annual Summary and Technical Appendix - http://www.sdge.com/regulatory/docs/eep_sdge.pdf

Ontario Power Authority
Supply Mix Submissions
175 Bloor St. E, North Tower Suite 606
Toronto, ON
M4W 3R8

**Supply Mix for Ontario's Electricity Market**

## I. Introduction

Cameco Corporation is pleased to offer its comments in response to the Ontario Power Authority's (OPA) request for submissions from stakeholders regarding OPA's planning for the long-term supply mix for the Ontario market.

Cameco Corporation, with its head office in Saskatoon, Saskatchewan, is the world's largest uranium producer as well as a significant supplier of uranium conversion services. Cameco's uranium products are used to generate clean electricity in nuclear power plants around the world, including Ontario, where the company is a partner in Bruce Power, North America's largest nuclear electricity generating facility. Cameco is the only commercial supplier of natural $UO_2$ for use in Canadian CANDU heavy water reactors with significant sales to its largest customer, Ontario Power Generation. Cameco's uranium refining and conversion facilities are located in Blind River, Ontario and Port Hope, Ontario.

In Cameco's opinion, nuclear energy must be a significant part of Ontario's supply mix. The economic, security and environmental advantages of this source of electricity are compelling. Other forms of generation must also be part of Ontario's generation portfolio to both provide diversity of supply (coal, gas, uranium, etc.) and generation variety (baseload, intermediate, peaking or intermittent). Such a mixed portfolio will lead to optimal security of long-term supply, an ability to match time-dependant demand profiles with appropriate generation assets, and sufficient competition amongst suppliers, all to the benefit of the Ontario consumer.

## II. Specific Comments

Cameco's specific comments are provided in response to the four "issue areas" identified by the OPA, as per the request for submissions:

1) Appropriate Analytical Planning Approaches

This particular issue area seeks advice on assessments of the risks that could affect portfolio performance, including financial, market, environmental and other quantifiable and qualitative risks. Consideration should be given to the following risk factors:

- Reliability of fuel supply, including risks of fuel supply interruptions due to transportation impediments, geopolitical stability and timely availability of renewable energy sources;
- Projected fuel costs and volatility of fuel prices due to fundamental supply/demand imbalances;
- Environmental and health risk factors, including potential spills, leaks and airborne emissions and risks of events occurring in populated areas;
- Risks of increased costs due to external and internal costs such as compliance with Kyoto or other clean-air protocols and regulations;
- Risks of overbuilt capacity resulting in financial distress to generators and uncertainty in the retail market (for example, an overbuilt generation market in the UK resulted in the near-bankruptcy of British Energy, resulting in market uncertainty).

A balanced approach to risk assessment, through the consideration of all potential market disruptions or ancillary costs, should result in a defensible model of a portfolio of supply options. It will be important to assess such risks, wherever possible, on hard scientific and statistical evidence.

2) Appropriate Approaches to Constructing Conservation and Demand Management Portfolios

Cameco supports conservation and demand management initiatives undertaken by the OPA and the Ministry of Energy. Such initiatives clearly demonstrate a commitment to sustainable and responsible development. However, as this is not an area in which Cameco has expertise, no specific comments are offered on this issue area.

3) Assessments of Different Supply Technologies and Resources in the Ontario setting

There have been several recent credible assessments of different supply technologies in the Ontario market and other similar markets. Cameco is pleased that the OPA specifically wishes to include nuclear as part of its overall consideration. There have been several studies done recently that compare various technologies, including nuclear:

- In August 2004, the Canadian Energy Research Institute (CERI) published "Levelised Unit Electricity Cost Comparison of Alternate Technologies for Baseload Generation in Ontario. The complete report is available at http://www.ceri.ca/Publications/LUECReport.pdf
- About the same time in 2004, the University of Chicago, in conjunction with Argonne National Laboratories, published a comparative study of nuclear power versus other technologies in "The Economic Future of Nuclear Power, available at http://213.130.42.236/wna_pdfs/uoc-study.pdf
- In May, 2005, the Council for Science and Technology published "An Electricity Supply Strategy for the UK", available at http://www.world-nuclear.org/opinion/cst-report.pdf

While each of these studies conclude that nuclear power is necessary as part of the supply mix in the jurisdiction studied, the main value is in the analytical approach used in the study for the comparison of technologies. Cameco encourages the OPA to use similar approaches found in these studies, but to update the input assumptions for the recent price rises in the various fuel supplies. Further, the OPA should perform sensitivities of various future fuel price scenarios to test the robustness of the economics of each supply option.

4) Appropriate Methods to Assess the Impact on the Natural Environment of Supply Options

There exists an established process under the authority of the Canadian Nuclear Safety Commission (CNSC), with its requirement to do complete environmental assessments of the construction, refurbishment and/or operation of a nuclear power plant. An excellent summary of Bruce Power's environmental assessment process and scope can be found at http://www.brucepower.com/bpcms_web/uc/GetDocument.aspx?docid=991. In addition, the Environmental Assessment for the restart of Bruce A Units 3 and 4 as well as the Pickering A restart can be found in the archives of the CNSC.

An appropriate environmental analysis would consider the life cycle impacts of each generating technology, from fuel production through plant construction, operation and decommissioning. Included would be the impact on greenhouse gas emissions of the various supply technologies. As has been well-reported in the mainstream media, only renewable, hydro and nuclear energy supply provide miniscule greenhouse gas emissions over the life cycle. An excellent, recent study of the role of nuclear power in reducing $CO_2$ emissions, commissioned by the US-based Nuclear Energy Institute, is found at http://www.nei.org/documents/Polestar_Northeast_GHG_Study_6-7-05.pdf. This study looks specifically at greenhouse gas emissions reductions in the adjacent Northeastern United States area. It is crucially important for the OPA to consider Canada's commitment to the Kyoto Protocol and the goal of reducing greenhouse gas emissions, in its consideration of supply mix. Obviously, Ontario is embarking on a gradual phase-out of the coal-fired generating stations to achieve this objective and must consider the role of nuclear power in replacing that generating capacity.

## III. Summary

Cameco believes that the economic, environmental and social advantages of nuclear power are evident in the various credible assessments published recently. Further, the studies referenced above are meticulous and balanced in their approach and provide valuable insights into analytical considerations for all generating technologies.

Cameco is prepared to further discuss its viewpoints with the OPA at any time and will continue to support OPA's efforts to fairly and comprehensively evaluate long term supply options.

For further information, please contact Stephen V. Lowen, Director Corporate Development and Power Generation, at (306) 956-6222.

Cameco Corporation
2121 - 11th Street West
Saskatoon, Saskatchewan
S7M 1J3

Ontario Power Authority;

Citizen's submission

supplymixsubmissions@powerauthority.on.ca

I understand that the Ontario Power Authority is accepting submissions from interested parties on aspects of the future of the electricity supply in the province of Ontario.

May I take a moment to introduce myself:

My name is Douglas Campbell and I recently took early retirement from Ontario Power Generation. For the last ten years I was the Chief Engineer at the OPG Lennox Generating Station near Bath Ont. During my career I held several operating positions in different Ontario Hydro fossil powered stations and provided technical support and project management for fossil stations from head office and commissioned large fossil utility generating units. Functioned in operating positions at the Bruce Nuclear Station, and supervised the conversions of Lennox GS units to natural gas.

I strongly support green energy and belong to **"Switch**" in Kingston but my association with the green energy movement has revealed the high price consumers and business will be forced to pay if we move too quickly without a balanced and well measured approach. Wind, solar, biomass, and natural gas have there place in the energy mix but not if the price is out of balance with the product.

We cannot remain locked in the thinking of the past and continue to consume natural gas to make electrical power when it should be reserved for domestic heating. This fuel is ideally suited for the domestic application and should not be **squandered** in power plants where other less precious fuels can be efficiently managed.

Ontario can turn a liability into an asset by recognizing the potential that still exists on the OPG Coal fired generating sites. It has been demonstrated that clean coal technology utilizing coal gasification cells are as clean and environmentally benign as natural gas . The existing OPG coal fired generation stations have coal receiving and handling facilities, switch yards and trained staff. All that is needed is leadership. Coal reserves exceed gas and oil reserves many times over and are in less demand, this will maintain the cost low.

The lead time to put in place new clean coal technology electrical generation would not be much greater then building a natural gas plant.

Diversity in the types of fuels will ensure reliability and competition and reduced cost of electrical power. Ontario must be self sufficient in electricity supply to provide a stable business environment.

If you wish to discuss this topic further I am available.

Regards

Douglas R Campbell

Canadian Bioenergy Association

Suite 318-1769 St. Laurent Blvd., Ottawa, Ontario K1G 5X7
Fax: (613) 521-1997 E-mail: info@canbio.ca Web: www.canbio.ca

Attention: To whom it may concern, August 25, 2005

Ontario Power Authority
Supply Mix Submissions
(By e-mail: supplymixsubmissions@powerauthority.on.ca )

**Canadian Bioenergy Association (CANBIO) comments to OPA on Ontario Supply Mix**

CANBIO is a national, industry-driven, non-profit organization of individuals**,** businesses and non-governmental organizations interested in the development, promotion and use of bioenergy.

**Our Mission**: To promote industry and public support for increasing awareness, development and use of renewable, sustainable and environmentally-responsible biomass energy.

CANBIO is pleased to have the opportunity to provide some initial comments to the OPA relating to Ontario's electricity supply mix, and as noted in the closure of our letter we would be pleased to met with the OPA or its consultant to discuss further information requirements. We note that a number of comments have been made to the OPA through the RFP assessment process, some of which are applicable to bioenergy development. As requested, we've structured our comments to correspond with the information requirements outlined in the call for written submissions.

**Minister's specific requests:**

- Recommendations with respect to additions of new renewable energy capacity by 2015, 2020 and 2025 taking into account the targets already set by the Government of Ontario for 2007 and 2010, and

**Response:** CANBIO made a presentation to the Electricty Conservation and Supply Task Force on August 14, 2003. Though it is somewhat dated, and was not based on a rigorous analysis, this presentation is attached for your information. At that time a conservative estimate was made of the potential undeveloped biomass electrical energy potential in Ontario of 1700 MW and 12 TWh per year.

**OPA issue areas:**

**Issue 1**

- Appropriate analytical planning approaches that focus on assessment of risks, environmental attributes and cost characteristics of various portfolios. The approaches

will be of the greatest value where they include assessments of the risks that could affect portfolio performance, including financial, market, environmental and other quantifiable and qualitative risks;

**Response:** CANBIO recommends that planning approaches should ensure the attributes of bioenergy (many of them unique) are fully recognized, quantified, valued and appropriately considered:

- Significant environmental benefits through reductions in GHG emissions and other pollutants compared to fossil fuels
- Economic impacts of local job creation related to biomass feedstock acquisition
- Addition of value and improved economics to Ontario's forestry and wood processing industries based on their natural synergy with bioenergy
- The energy in biomass is storable and transportable. New and emerging collection, processing and utilization technologies, combined with increasing value of biomass for meeting GHG commitments on a global scale will create opportunities for suppliers to economically transport it farther than is being done now. This is an opportunity for increased local (within Ontario) use of supplies that may not be economic now. If economic conditions favour out of province or even off-shore export, the environmental benefits may be lost to Ontario and Canada.
- Increasing conventional energy costs are driving the increased use of bioenergy within the forestry and wood processing sectors, and in some locations in central and eastern Canada conventional supplies of mill residues and wastes are therefore decreasing. Forest floor biomass (the unused harvesting residue) is a very large source of bioenergy that is largely untapped. The evolving opportunities and issues relating to forest floor biomass need to be considered. There is an opportunity for governments to create an environment that favours use of forest floor biomass for bioenergy. *CANBIO is conducting a workshop in Quebec City on September 8, 2005 to explore the opportunities and issues relating to forest floor biomass. The web link is:* *http://www.canbio.ca/pdf/Quebec%20workshop.pdf*
- There may be potential for using biomass energy crops for bioenergy power production. The current economics don't support this however at some point energy values will likely make the use of some biomass energy crops feasible.
- Unlike wind, solar and small hydro renewable technologies, bioenergy is dispatchable. It also has a high capacity factor relative to other renewable technologies.
- Bioenergy projects require a secure long term fuel supply at a predictable cost. They also are often located at a host site that buys steam and electricity. When fuel supply and

project electricity and thermal product sales are linked to forestry and wood processing industries, supply and project economics can be impacted by company closures and trade disputes (such as the softwood lumber dispute). OPA bioenergy based power procurement processes should allow flexibility for such cases. Specific comments have been made in this regard by a number of respondents to OPA's request for information on the RFP processes.

- There is considerable potential to increase the extent to which bioenergy can contribute capacity and energy to Ontario's electricity supply mix. This potential will only be realized if there is a long term stable climate for investment and reasonable procurement processes for bioenergy, specifically:
    - Allowing developers to appropriately access the value of all environmental attributes
    - Policies to encourage utilization of forest floor biomass
    - Allowing developers to access the value of the unique dispatchability, predictability and reliability of biomass based generation
    - Connection policies and rules that allow projects at host electricity and thermal customer sites to avoid the transmission and distribution costs associated with electricity generated and consumed on site
    - Designing procurement processes to be realistic with respect to eligibility requirements and reasonable with respect to risk allocation, development effort to achieve a contract, power pricing and flexibility to accommodate future changes.

**Issue 2**

- Appropriate approaches to constructing Conservation and Demand Management (CDM) portfolios for inclusion in long-term plans. These approaches will be of the greatest value where they include established data on technical and achievable potential, costs, implementation barriers, sector specific characteristics, experience in implementation of CDM and technology developments;

**Response:** CANBIO agrees CDM should be an important part of the supply mix. Dispatchable bioenergy generation at local electricity customer sites could be used to manage the customer demand from the grid.

**Issue 3**

- Assessments of different supply technologies and resources in the Ontario setting, including, but not limited to, natural gas generation, coal gasification, nuclear (new and

refurbished), wind, biomass and hydro-electric resources. The assessments will be of the greatest value where they:

- Use recent source information or current data on capital and operating costs, performance characteristics, technology life cycle, environmental impacts and any other relevant characteristics, and
- Present data on a consistent basis across the supply technologies and resources that would be suitable for planning studies.

**Response:** There are many sources of information on both conventional and emerging biomass based generation from many jurisdictions. CANBIO made a presentation to the Electricty Conservation and Supply Task Force on August 14, 2003. Though it is somewhat dated, this presentation is attached for your information. CANBIO would be pleased to meet with OPA or its consultant with a view to determining specific information requirements and providing specific relevant information and sources of information to OPA.

**Issue 4**

- Appropriate methods to assess the impact on the natural environment of supply options. The methods will be of the greatest value where they are:
  - Methodologically suited to long-term planning;
  - Provide for identification and quantification of relevant environmental factors for assessment;
  - Capture the cumulative environmental impacts; and
  - Provide indications of the sustainability of options and supply mix plans.

**Response:** CANBIO recommends the assessment methods should:

- Be able to model and address the opportunities and issues identified in Issue 1.
- Allow for flexibility of changing assumptions throughout the modeling timeframe. For biomass based bioenergy particularly important parameters include: local and global values of CO2 and methane reductions, value of SOX reductions, quantity and cost estimates of economically usable biomass feedstocks, changing costs of emerging and developing generation technologies, extent of tradable renewable credits markets.

CANBIO thanks you for the opportunity to comment. We would be happy to meet to discuss any further information requirements and provide additional information.

Sincerely,

Bruce McCallum, President CANBIO
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Canada's Chemical Producers / Fabricants de produits chimiques du Canada

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**VIA E-MAIL**

# Memo

**To:** Ontario Power Authority (OPA)

**From:** David Goffin

**CC:** Minister Dwight Duncan

**Date:** August 4, 2005

**Subject:** Call for Written Submissions on the Future Electricity "Supply Mix" for Ontario

---

The Canadian Chemical Producers' Association (CCPA) represents leading companies engaged in the business of chemistry. This is a $10 billion a year business for CCPA's basic chemicals and resins manufacturers in Ontario through which they provide the basis for the broader $24 billion a year chemical manufacturing sector. Chemicals is a keystone sector of the provincial economy with strong supplier and customer linkages with other major sectors and clusters identified by the government as priorities (e.g. Automotive; Pharmaceuticals and Biotechnology; Agriculture and Food Processing; Information and Communications Technologies). Electricity is an important investment and profitability factor for Ontario's industrial chemical sector.

The call for written submissions identifies four "issue areas" for which the OPA is seeking specific advice from interested parties in the nature of data; analytical planning approaches; assessments; methodologies and so forth. We believe that generally, the specific information that we expect other parties will provide in these four areas will be appropriate for assisting the OPA in developing its advice for the Minister of Energy on the province's future supply mix. Neither CCPA nor our member companies, however, can provide any such specific information or data.

One of our member companies has suggested that the process should start with key principles consisting of bearing the long-term supply/demand approach in mind; focusing on lowest lifecycle cost of supply sources rather than preferential fuel supplies; balancing the supply portfolio of base load and peaking to reflect consumer usage patterns; and providing a policy environment that includes both independent and crown-owned generation facilities. Another member comments that any impacts of future supply sources on the reliability of the electrical distribution grid should be taken into account by the OPA. This is one of the major electricity issues facing our Sarnia-Lambton companies and it affects both the safety and competitiveness of their operations. Other companies comment on the importance of fair treatment for distributed generation, including co-generation, in the supply mix. It is deplorable that this summer Ontario companies have been asked to reduce electricity consumption and hence output, while already installed co-generation capacity cannot be used.

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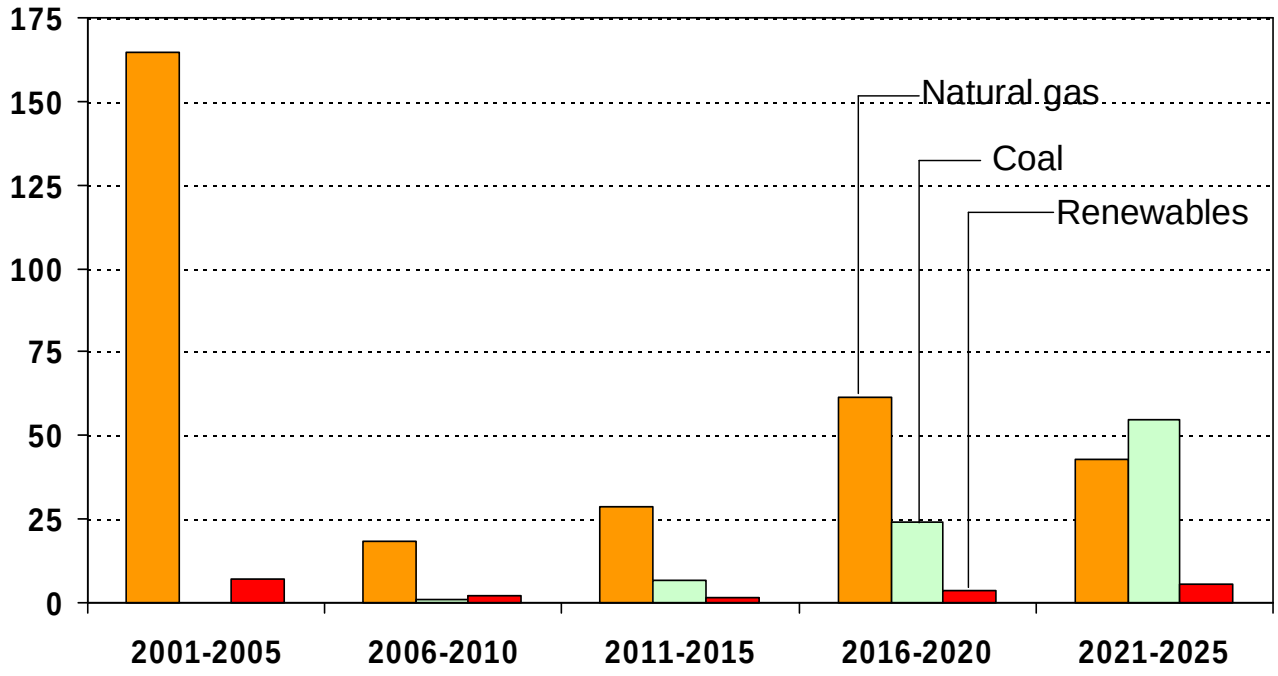
The OPA's collection of specific information in the four issue areas should allow it to, among other things, evaluate the forecast cost of electricity from the categories of potential supply sources. We recommend that this evaluation should extend to comparisons of the competitiveness of these expected costs with electricity costs in competing jurisdictions. In our view, the Ministry of Energy and the government generally has given short shrift to the need for a competitive electricity system to support the province's industrial base. The one exception to this has been the Ministry of Economic Development and Trade which has worked with industrial consumers to better understand the competitiveness impacts.

In recent weeks, in addition to chemicals northern Ontario's forest products sector, and major companies in the mining and smelting and automotive sectors have identified electricity as a serious competitiveness factor which is influencing how they view Ontario's competitiveness. We trust that these growing voices of concern will help convince the government to give competitiveness greater weight in the future electricity decision-making process, including decisions about the supply mix.

In considering this, we believe that it is useful to take into account where the U.S. is headed in comparison to the opportunities available to Ontario. We make this suggestion not because that country has all the answers--clearly, it doesn't--but rather, because it provides our most important markets as well as our greatest competition in those markets. The chart below provides the U.S. Energy Information Administration's (EIA) projections of electricity generation capacity additions by fuel type to 2025.

**Electricity Generation Capacity Additions by Fuel Type, 2001-2025 (gigawatts)**




The EIA projects that continued growth in electricity sales of 1.9% annually will drive new electricity capacity additions in the U.S. It expects most of the additions to be natural gas-fired combined cycle, combustion turbine or distributed generation technology. This emphasis on using increasingly scarce natural gas for power generation has stretched North American natural gas markets and driven up the price of natural gas. The EIA believes that the natural gas for additional power generation will be sourced primarily from new and expanded Liquefied Natural Gas (LNG) terminals.

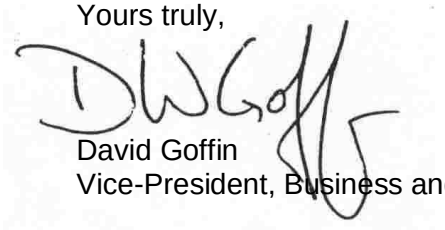
This source of natural gas may or may not materialize in the quantities required in the U.S. but for Ontario, relying on LNG would be even more problematic. It would require the approval and siting of LNG terminals in other provinces; decisions by players in those provinces to service the Ontario market; and expansion of infrastructure in those provinces and in Ontario to make that a reality. CCPA urges the OPA and the Ontario government to take these factors into account, as well as the impacts on natural gas markets, when considering additional natural gas-fired electricity generation.

The continued U.S. reliance on additional natural gas-fired generation foreseen by the EIA may not happen. The just passed U.S. energy bill is based upon President Bush's 2001 plan to create diversity in energy supplies in order to, among other objectives, alleviate the stress on natural gas supplies and reduce natural gas costs. It includes incentives for the U.S. power industry to invest in coal gasification and in the new generation of nuclear power plants. The EIA's projections already expect major new coal-fired electricity generation to become operational after 2015 as pulverized coal and advanced clean coal technologies become available and increasingly competitive. Clearly, in order to remain competitive, coal must be part of Ontario's future supply mix.

The EIA does not project any nuclear power capacity additions. That may change due to the energy bill provisions. If it does not, Ontario will have the opportunity to gain competitive advantage by making appropriate use of nuclear power within its own supply mix. The EIA recognizes the role of renewables but does not expect these sources of electricity to become appreciably more important by 2025. Those involved in the U.S. renewable sector believe that energy bill provisions will help to jump-start these sources of electricity.

We trust that these general comments will be helpful and regret that we cannot provide the type of specific information requested by the OPA. During August CCPA plans to discuss this matter with the Association of Major Power Consumers in Ontario (AMPCO). After we do so, we may submit further comments.

Yours truly,



David Goffin
Vice-President, Business and Economics

DWG/lg

CDEA/ACRT
Canadian District Energy Association
Association Canadienne des Réseaux Thermiques

August 19, 2005

Ontario Power Authority,
175 Bloor Street East, Suite 606,
Toronto, Ontario M4W 3R8

Attention: Dr. Jan Carr
Chief Executive Officer

Dear Dr. Carr,

**Subject:** Ontario's Future Supply Mix

In response to the OPA's Call for Written Submissions, the Canadian District Energy Association ("CDEA") is pleased to provide one primary recommendation for the OPA's consideration with supporting comments relating to several of the identified 'issue areas'.

## Primary Recommendation

*Ontario energy policy and market mechanisms should evolve over time to pro-actively increase the percentage of high efficiency and renewable embedded ("distributed") generation capacity in the Province of Ontario to no less than 25% by the year 2025.*

## Discussion

While most industry stakeholders recognize that there are system benefits that accrue from embedded generation projects, the CDEA recommends that the OPA should quantify these benefits, compare the macro-economics to a "transmission system dependant" model, and confirm and recommend system wide targets for embedded generation.

The specific target of no less than 25% by 2025 does not result from a rigorous analysis. Rather, it is more intuitive based on a realistic assessment of generation capacity that could be annually added to the growing system. If one assumes that total system installed capacity will exceed 30,000 MW in twenty years[1], a 25% embedded generation component would exceed 7,500 MW in 2025. This represents, on average, between 350 and 400 MW of new embedded capacity added to the system annually.

Less than 5% of generation in the Province today is embedded. A supply mix strategy with no less than 25% embedded generation results in a more efficient use of non-renewable resources, is more responsive to changing load forecasts, and provides a significant shift in our ability to manage transmission grid disruptions that could result from weather events, technical failure or deliberate acts.

[1] Navigant Consulting: Report: Avoided Cost Analysis for the Evaluation of CDM Measure June 14, 2005 Table 1: Forecast Annual Energy Consumption and Peak Demand.

**Long-Term Planning:**
A system mix with a large embedded generation component is more responsive to a changing load forecast. The planning, approvals, and construction cycles are typically less than three years with some projects less than 18 months. However, it is important to create a stable policy and price environment in order to ensure that a large number of projects are in development at all times. If our Government fails to create a stable policy environment, and we have a sudden shift in the demand-supply balance, the only solution available to the OPA would be contracting for the immediate construction of large combined cycle gas plants.

On a related point, small distributed generation projects are not typically a target of the growing NIMBY trend that is evidenced in York Region this past year or the public's response to several of the CES plants that won contracts as part of the 2,500 MW RFP. Small distributed generation projects will have a high likelihood of being constructed and not experience opposition from the local community if the projects deliver other local benefits.

**Electricity System Efficiency:**
As discussed at a recent OPA stakeholder meeting, the CDEA and other stakeholders have presented our high level analysis of the "value" of system benefits that accrue from embedded or distributed generation projects. Most notably, embedded projects avoid transmission and distribution system losses:

1. Avoidance of marginal transmission system line losses during peak and mid-peak periods equal to 9.0%[2].
2. Avoidance of distribution system line losses during peak and mid-peak periods equal to 4.0%.

**Security of Supply:**
Ontario electricity consumers are overly dependant on the aging transmission system. With the August 2003 blackout as a recent memory, it is our view that consumers will embrace a strategic shift to an energy policy that targets a much higher percentage of embedded supply that does not depend on the high voltage transmission system.

**Natural Gas Price & Supply:**
A common concern of a growing natural gas fleet in Ontario is the pressure on both natural gas pricing and the long term limitation of natural gas supply. The incremental volume of natural gas for a fleet of intermediate power, high efficiency

[2] Navigant Consulting: Report: Avoided Cost Analysis for the Evaluation of CDM Measure June 14, 2005 Table 10: Transmission Losses by Season and Time-of-use Period.

natural gas CHP plants will be significantly less than a combined cycle plant of the same net output.

**System Cost Impacts:**
Embedded generation projects will ease the strain on the transmission system and local distribution systems which will extend the life of the existing assets and defer future capital investments.

As presented to the recent OPA stakeholder meeting, the CDEA tabled an analysis which illustrates system benefits that accrue from high efficiency CHP plants that would be constructed as part of community district energy systems or serving the MUSH sector. If all system benefits are recognized, projects that are embedded can compete with larger projects that depend on the high voltage transmission system.

Projects that are embedded in communities or behind customer loads offer a number of other cost benefits that go beyond electricity rates. For example, a high efficiency combined heat and power plant that delivers electricity and thermal energy to a hospital connected to a district energy system will (a) help the hospital reduce their capital budget (b) provide additional emergency power capacity and (c) reduce their long-term operating budget.

**Fuel Diversity:**
While a high percentage of the projects that will be constructed in the near term will utilize natural gas as the primary fuel, many examples of embedded projects will adapt to alternate and locally available fuel sources in the future. An example of this flexibility is a district energy system that has constructed a thermal distribution system to serve a large community. The primary fuel may evolve from natural gas today to a bio-fuel in the future as energy from waste technologies mature.

These embedded or distributed generation arguments are well-known. The CDEA would recommend that the OPA seriously considers our primary recommendation of setting a system mix target for embedded generation in the same manner as it will determine targets for fuel types and project size diversity.

We appreciate the opportunity to provide our views and we wish the OPA success in completing this important directive.

Yours truly,

Bruce Ander, P.Eng.
Chair
**Canadian District Energy Association**

**Submitted to the Ontario Power Authority with respect to the "Call for Written Submissions on Supply Mix**

**August 26, 2005**

August 26th, 2005

Attn: Jan Carr
Ontario Power Authority
175 Bloor St. East, North Tower, Suite 606
Toronto, ON

Re: Supply Mix Submissions

Dear Mr. Carr,

The Canadian Energy Efficiency Alliance ('Alliance') is pleased to provide the OPA with our views on the future "supply mix" in Ontario. We represent many of Ontario's largest utilities, manufacturers, consumer groups and other non-profit organizations and have been a vocal advocate for many years in Ontario around energy efficiency. The Alliance has been involved in many advisory boards, policy submissions and OEB Stakeholder Consultations with respect to energy conservation and energy efficiency's role in Ontario's Energy Framework. The Alliance will continue to advance and advocate the importance of demand in any future energy market plan in Ontario and across the country.

In this brief submission, we have summarized our position relative to Ontario's long term supply mix plan. ***The key priority for the Alliance is to ensure that energy efficiency is represented in the long-term power system planning for Ontario***. In addition to this, the Alliance would like to see continuous improvement around energy efficiency standards for appliances and in residential and commercial building.

## Energy efficiency in the "supply mix"

The Alliance believes that energy efficiency must be a priority in the supply mix for Ontario's long-term power system planning. It has been noted by a number of experts including the Honourable Dwight Duncan, Minister of Energy that every kW saved is as good as a kW built.

The Alliance has formatted the components we feel are necessary to advance energy efficiency in Ontario into the four 'issue areas' that the OPA identified as important. Our position on the four 'issue areas' are applicable to both natural gas and electric DSM.

## I Risk assessment/environmental attributes of energy efficiency

While much in the long-term planning of the supply mix will focus on the need for new generation plants, and updating the transmission system, investment into energy efficiency should be considered for improving the electricity system in the short and long term. A study for the US National Association of Regulatory Utility Commissioners (NARUC) concluded that:

"energy efficiency investments can be viewed as a low-cost means of 'peak proofing' the electric system, keeping the electric grid intact during heat waves, cold snaps, and **other challenging events** (emphasis added)"

By 'peak proofing' the electric system, the risks of brownout or blackout occurring is reduced. When risk of a brownout or blackout is reduced, businesses are more likely to want to invest in Ontario. This business investment is in part due to increased confidence that their company will not face unexpected revenue losses as a result of energy stoppages.

The Alliance encourages the OPA to include the following consideration into the risk assessment model:

- ***Energy prices should reflect true costs***

  A well functioning market where prices reflect costs will provide appropriate signals to all market participants to allocate resources in an efficient manner. A price signal that reflects the true cost of energy will provide more accurate drivers to use energy wisely in the production, transmission, distribution and end use of energy. This will help to maximize the amount of energy efficiency and conservation that is achieved in a competitive market without additional assistance to overcome remaining market barriers.

- ***No undue burden should be placed on disadvantaged groups as a result of energy prices***

  Even with energy priced at its true cost, not all groups will have the ability to respond to these market signals adequately. In particular, low income groups do not have the resources to respond to higher prices. For example, some energy saving measures require up-front capital to minimize life-time costs, and low income groups may not have access to capital, or to credit.

Low income consumers represent 11.7% of Ontario residents.[1] Statistics Canada data show that in 2001, the lowest earning quintile of Ontario households spent nearly five times the percentage of their income on water, fuel and electricity than did the highest income quintile.[2] Low income households in Ontario are likely paying more per unit of energy (since electric heating is more expensive than other fuels and there is a far greater proportion of low income households that have electric heating) and may be using more energy per household (due to older appliances) than other households.[3] As a result, low income households represent a significant opportunity for energy savings.

## II Conservation and Demand Management (CDM) Portfolio development

The Ontario government has set a target to reduce demand 5% by 2008. Meeting this objective will require a dramatic change in our energy use habits and consumption patterns. To be effective a multi-faceted approach will be required. This approach would include a mixture of public education and social marketing efforts, policy instruments, and technological solutions. Following are the various approaches and instruments that will need to be applied to successfully engage and mobilize consumers in energy efficient activities.

*a) Community Based Social Marketing*

The Alliance strongly believes that successful demand-side management programs should follow the approach and characteristics of "community based social marketing". Furthermore, the Alliance suggests that if the OPA is considering developing and implementing demand side management programs, it would be helpful for the OPA to consider those programs within a community based social marketing context.

Community based social marketing has as its objective a change in social behaviour. It is action-oriented and emphasizes measurable change by removing structural and external barriers (e.g. cost, inconvenience). It is an effective approach because it is the most likely way to bring about behavioral change. Community based social marketing takes a pragmatic approach that involves:

- Identifying the barriers to a desired behaviour.
- Developing and piloting a program to overcome these barriers.
- Implementing the program across a community.

[1] Advocacy Centre for Tenants Ontario. Rental Housing in Ontario – quick facts. November 4, 2002.
[2] IndEco Strategic Consulting Inc. *DSM for Low Income Consumers in Ontario*. 2003.
[3] IndEco Strategic Consulting Inc. *DSM for Low Income Consumers in Ontario*. 2003.

- Evaluating the effectiveness of the program.

Successful social marketing initiatives are:

- *Sustained* – campaigns are implemented over a series of years, not weeks or months.
- *Evolving* – programs are monitored, measured, and refined.
- *Outcome driven* – not about the information to impart, but focused on the change to be wrought.
- *Targeting strategies* – define market segments by need, opportunity, accessibility, proclivity ("the ready…the willing…the able").
- *Motivating, enabling and reinforcing strategies* – actions are straightforward and convenient.
- *Diffusion of innovation strategies* – engage early adopters.
- *Partnership based* – inter-sectoral efforts create multiple opportunities and collective momentum for change.

*b) Mass Marketing*

Mass marketing campaigns require a significant investment in financial and human resources – not to mention capacity to effectively manage their delivery. To be effective however, mass marketing cannot be a one-shot effort. Sustained and multiple messages over 3-5 years are the key to successful mass marketing programs (this is not to suggest that the specific message doesn't change, but different messages "build" on each other). Mass marketing campaigns usually have limited impact on behaviour change. In addition, since mass marketing efforts contain relatively simple messages they cannot be targeted to key audience segments, and evaluation poses a problem. Although mass marketing is typically heavily used in outreach and education efforts, the Alliance feels that this tactic should be used sparingly if at all by the OPA in its long term planning.

*c) Economic Incentives*

Providing economic incentives through price signals can be a very powerful tool to encourage behavioral change on a "'micro-level". Economic instruments act as reminders of the consequences of purchasing decisions, thereby increasing consumer awareness. Example:

- Tax incentives, which encourage consumers to retrofit their homes.

The Alliance would strongly encourage the OPA to use economic incentives where possible to affect behavior change or encourage energy efficient purchasing decisions.

*d) Regulatory Incentives*

Regulations are often the push that is needed to ensure widespread behavioral change. However, to be effective, regulations must be enforced with specified penalties and targeted in the way they encourage behavioral change. The Alliance encourages the OPA to advance regulation improvements where possible (eg. Building codes, appliance minimum energy efficiency standards, etc.), and support regulation changes by educating consumers to ensure public acceptance and support of new regulations as they are put into place.

The Alliance encourages the OPA to consider the following:

- ***Coordinated and consistent public education programs on energy conservation and energy efficiency across Ontario should exist***

  The Alliance believes it is important to have broad-based, multi-faceted public education programs to help consumers make informed choices about their energy usage. To achieve economies of scale and to ensure consistency in the content and quality of the programs, we feel it is necessary to have a coordinated approach to design and delivery across the province. As well, programs should be multi-year campaigns to ensure ongoing learning in step with changes in technologies and available services. The success of the programs should be tracked for measurable savings and in order to ensure improvements are taking place year over year.

- ***Natural gas and electric utilities and provincial ministries/agencies should continue to be required to implement energy efficiency and energy conservation programs in their own operations and report on their progress.***

  Utilities and government have an important role to play as models of wise energy use. Natural gas and electric utilities as well as provincial ministries/agencies should be required to implement energy efficiency and energy conservation programs in their own operations. In order to demonstrate that the programs are effective, the organizations should be required to report annually on progress. Oversight for the utilities' performance could rest with the OEB, while oversight of provincial ministry/agency performance could rest with the Ontario Power Authority.

## III Supply technology and resource assessments in the Ontario setting

The Alliance believes that energy conservation can be provided at a competitive cost to new supply development. Previous studies by the Canadian Energy Efficiency Alliance, and others, have shown that increased energy efficiency results in net economic benefits. Furthermore, enabling the energy efficiency industry creates new local jobs for Ontarians. As energy costs rise, additional jobs and expertise in the energy efficiency

industry will provide economic advantages and international opportunities for Ontario businesses.

The Alliance encourages the OPA to consider the following in their analysis of supply technology and resource assessments in Ontario:

- ***Incentives are made available to encourage the introduction of new, more efficient technologies***

  Incentives need to be available to facilitate technology and information transfer. In addition, incentives should be available to encourage the early adoption of new more efficient and cost-effective technologies.

- ***Training and other programs are offered to ensure energy professionals and trades people are skilled at using the latest technologies and techniques***

  It is essential to have properly trained professionals and trades people in energy saving techniques and technologies. In particular, it is important for architects, engineers, developers, building owners and managers, and contractors to understand the latest developments, to be encouraged to implement them and to implement them in an effective manner.

  Organizations such as community colleges, universities, professional and trade associations and groups such as Sustainable Buildings Canada can play an important role in training and retraining. The OPA in the Alliance's view would be well positioned to take the lead role in facilitating the development of ongoing skills upgrading programs through the coordination of efforts among relevant ministries and agencies, professionals and trades people, associations, and other stakeholders.

- ***Facilitate the accelerated introduction of high efficiency distributed generation technologies***

  Distributed generation is the application of small-scale generating technology (since generators brings to mind diesel and gas machinery) - typically several hundred kilowatts in size - at a consumer's site rather than large centralized power stations. Energy available at the site is used to produce electricity, which can be used either at the site or fed into the electrical grid. The Alliance advocates a wider use of distributed energy resources including: cogeneration, fuel cells, solar, wind, biomass and ground source heat pumps. The Alliance suggests that the benefits of distributed generation such as countering existing distribution constraints, deferring distribution upgrades, reducing the need for additional

transmission capacity, reduced losses in transmission, improving the reliability of the existing system and reducing greenhouse gas emissions should be considered in the development of distributed generation components within Ontario's long term supply mix planning.

## IV Environmental impact of energy efficiency

Energy conservation and energy efficiency provide the least environmental risks of any energy source. If a kW saved is as good as a kW built, and there are no environmental risks to saving a kW, then it follows that energy efficiency is the energy supply option that provides the least environmental impact. This means that from an environmental impacts standpoint, the Alliance advises the OPA to consider energy efficiency as the optimum option.

Thank you for the opportunity to provide our views on the long-term planning of supply mix in Ontario. We hope our opinions have been helpful and would be pleased to spend time discussing them with you in further detail.

Regards,

- *Original copy signed* -

Ian Morton
Executive Director, Canadian Energy Efficiency Alliance

Copy: Peter Love, Chief Energy Conservation Officer, Ontario Power Authority
Marion Fraser, Senior Policy Advisor, Ontario Ministry of Energy
Board of Directors, Canadian Energy Efficiency Alliance

Canadian Manufacturers & Exporters
Ontario Division

SEP 0 8 2005

Via Mail: Sandra. c.c. P. Bradley c.c. A. Slalabg

Rec'd: SEP 0 9 2005

August 26, 2005

Jan Carr
Vice Chair
Ontario Power Authority
2300 Yonge St
PO Box 2319
Toronto, ON M4P 1E4

By Fax: 416.440.7656

RE: Written Submission on Electricity Supply Mix in Ontario

Dear Mr. Carr,

On behalf of Canadian Manufacturers & Exporters (CME), I am pleased to provide input that will help the OPA in their recommendations to government on the appropriate supply mix for Ontario. Although the supply mix is only one component of a complex energy system in Ontario, it is absolutely critical to the vitality of the manufacturing sector in Ontario and society as a whole.

CME is Canada's leading business network. Our members represent 75 percent of manufactured output in the Province (and the country) and 90 percent of all exports. CME provides advocacy and education services for members on timely and relevant issues. In response to a growing concern for energy issues in general, CME formed the Standing Committee on Energy Policy, which has contributed to the formulation of this document.

Manufacturing is important to the province of Ontario. It is the single largest sector of the economy (17.5 percent of GDP), employing over 1,000,000 people directly in this province. In Ontario, wages in the manufacturing sector are 25 percent above the national average and, for every $1 invested in manufacturing; there is an additional $3.05 in economic activity. It is therefore necessary that supply decisions be made in the context of an industrial strategy for Ontario.

Electricity is significant to manufacturing. Electricity is the primary source of energy for the manufacturing sector. [1] A powerful example of the importance of electricity to the economy was the Blackout of August 2003, which caused a $10 billion decline in Canadian manufacturing shipments.

Furthermore, according to CME's 2005 *Management Issues Survey,* one quarter of respondents cited reliability of energy supply as a constraint on future investment in Canada. CME's objective is to reduce the number of respondents concerned with energy supply reliability to zero by 2020. Fuel mix will play a critical role in achieving this objective.

[1] http://www40.statcan.ca/l01/cst01/prim74.htm?sdi=energy , 2004

6725 Airport Road, Suite 200
Mississauga ON L4V 1V2
Tel: 905-672-3466
Fax: 905-672-1764
www.cme-mec.ca

Electricity prices have escalated dramatically recently. From the first quarter of 2000 to the first quarter of 2005, electricity prices rose by 18.5 percent while selling prices have increased by only 4.2 percent over the same period. Recent government policy decisions including the decision to phase out all coal-fired generation and RFP contracts will virtually guarantee higher prices for electricity. Manufacturers recognize that electricity prices are likely to go up as a result of increasing fuel costs globally; increasing demand; increasing concern for health impacts and the acceptance of a reasonable rate of return for generators.

However, Ontario must not become an island of higher priced electricity relative to other jurisdictions that are competing for investment. Ontario electricity prices are already uncompetitive, resulting in some industries, including chemical and pulp and paper industries, leaving the province. The implications are particularly severe in Northern Ontario where communities rely entirely on mining and pulp and paper industries to survive. Although these industries are being hit severely, all industries in Ontario are affected by escalating prices and it is only a matter of pennies per kw/h before more industries close Ontario facilities. It is therefore critical that the cost of supply options be considered in relation to other jurisdictions.

It is under these circumstances that CME has framed the response to the OPA's request for input.

**OPA Issue areas for supply mix:**

***Appropriate Analytical Planning Approaches:***

The most important factor in analytical planning for the supply mix must be cost optimization. The OPA should be concerned with considering the socioeconomic implications of various supply options. Cost analysis has been seriously lacking in recent decisions including the 2500 MW RFP, the renewables RFP and the decision to phase out coal fired generation in the province. It is imperative that any analytical models include consideration of economic and social implications and at the very least, predicted costs associated with each supply option.

Implicit in cost optimization is cost containment. Industry supports paying the "true cost" for power, provided that the costs are transparent and reasonable; and that measures are in place to control costs. CME believes that cost containment must be within the scope of the fuel mix recommendations. In comparing fuel options, the ability to contain costs should be factored for both proven and new technologies. Stranded debt associated with cost over-runs at Ontario Hydro is seriously impeding the success of the present electricity system in Ontario.

CME recommends that the OPA use a reliable and independent third party resource for cost information like; Canadian Energy Research Institute (CERI) or the National Energy Board. The Centre for Spatial Economics has released a report on the economic impacts of various supply options that should be considered.

***Conservation and Demand Management***

If the OPA is considering recommending an RFP for Conservation and Demand response, the RFP should avoid being prescriptive and give candidates time to develop proposals that meet the government's objectives and any rules for each option. CME would be pleased to assist the OPA further in creating an effective RFP CDM projects.

It is critical that Demand Management and Conservation programs recognize the investment and contribution that industry has already made in these areas. According to the Canadian Industry Program for Energy Conservation (CIPEC), manufacturers have reduced overall energy intensity by 8.1 percent since 1990. Therefore, conservation programs in general must avoid cross-subsidization. This would send negative signals to early adopters that they would have to pay for electricity consumers that have not been proactive regarding conservation.

***Assessment of Different Supply Technologies***

CME supports the development and implementation of renewable technologies provided that they are cost competitive and reliable. A diverse supply of electricity generating options is not only favourable, it is necessary. All sources that are currently available will need to be further developed in order to meet projected demand. Rather than picking sources of fuel on an ideological basis, the government should look to set criteria for generation based on desirable health, social and environmental outcomes. This process will yield the optimal supply options for consumers.

For example, CME believes strongly that coal has been dismissed as a fuel source without adequate consideration of the potential for environmental and health improvements and the advantages of coal fired generation from a cost standpoint.

***Appropriate Methods to Assess the Impact on the Natural Environment of Supply Options:***

The appropriate method for determining environmental impacts of various supply option would be to use existing, peer reviewed data on various options. It is critical that the data be transparent and reviewed by an independent third party. From that data, the OPA, in conjunction with the Ministry of Environment, should extract the types of emissions that are deemed to be harmful, and set standards based on reducing those harmful emissions. In the final assessment of the sustainability of various supply options, the environmental impacts would be considered equally in conjunction with social and economic impacts.

**Conclusions:**

OPA's assessment of the fuel mix cannot be made in a vacuum. Ontario is and will continue to be an industrial economy that allows Ontarians to enjoy a quality of life that is second to none.

Ontario needs an electricity system that supports a growing and prosperous manufacturing sector. In order to achieve this type of continued prosperity, the fuel mix over the next 20 years will be critical. Ontario society has thrived on competitively priced electricity for the past 100 years. There is no reason why Ontario can't maintain that competitive advantage for the future by making the right choices for the fuel mix.

To achieve the most cost effective and environmentally sustainable electricity system in North America, the OPA will have to recommend generating solutions that meet environmental standards and offer the best price and reliability for consumers. CME believes strongly that the correct fuel mix will yield lower cost solutions without compromising the integrity of our natural environment.

Sincerely,

Paul Clipsham TAA

Paul Clipsham
Policy Analyst
Canadian Manufacturers & Exporters
905-672-3466 Ext. 236

**Suggestions for Ontario's future electricity supply mix.**
(Demand side point of view - part of an overall sustainable energy-water strategy)

I work for the Canadian Federal Housing Agency - CMHC - Canada Mortgage & Housing Corporation. My focus is on demonstrating Healthy Housing and encouraging More Sustainable Communities. You may be familiar with the "Toronto Healthy House" (1996), for which I was the CMHC project manager.

My reason for writing is to offer some suggestions "towards a more sustainable energy-water strategy" This is something I would really like to contribute to - particularly to counter a "Nuclear Renaissance". Heck, I was helping to build 550 Megawatt nuclear power stations in 1961 as a trainee-apprentice.

Here are some suggested "sustainable energy topics" (I'm sure we have several more):
- On-site Utilities (eg. EcoNomad, Waterloo-BioFilter) instead of only Mega-Infrastructures.
- Integrating Housing & Vehicle energy systems (eg: electric cars permit major GHG reductions).
- Peak Shaving and Capacity Stretching (eg: households with grid-intertied battery-inverters).
- NetPositive Energy Housing (eg: with photovoltaic, microwind, and local co-generation).
- Energy & Water Monitoring of buildings (eg: internet based real-time management).
- Housing Forms that reduce vehicle dependence (eg: Fused Grid street patterns).
- Housing EcoSystems with a "Net Positive EcoFootPrint" that restore local Ecologies.
- Healthy Ventilation Strategies that avoid 5kWh/day energy burdens for each household.
- Lighting Strategies (streetlights too) that reduce energy demands and cooling loads.
- Ground Source Heat Pumps for heating and cooling load management.

Myself, I'd like to see 2-5 kWh/day targets for NPHH - NetPositive Healthy Homes,
plus 5-20 kWh/day extra for an electric car (range between charges 200-360 km )

I would be glad to explain these "Demand Side" approaches in more detail, if you are interested. Sorry if this rushed note is overly condensed - it is end of day Friday.

Chris

*PS - I also enclose details of a recently announced CMHC initiative*
*Canadian Net Zero Energy Healthy Housing*

Christopher Ives
Senior Researcher
Housing Technology Group
Policy & Research Division
Canada Mortgage and Housing Corporation

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**Canadian Net Zero Energy Healthy Housing Initiative**

## Message from Doug Stewart
## Vice-President, Policy and Planning

### Launch of Phase I of a Canadian Net Zero Energy Healthy Housing Initiative

July 20, 2005

I am pleased to inform you that Minister Fontana announced today a contribution of $1 million by CMHC to launch the first phase of a Canadian net zero energy healthy housing initiative. This initiative is a government/industry partnership that builds the vision for a clean energy future and healthy communities through application of the healthy housing principles.

The goal of net zero housing is to create homes that will ultimately have a zero net consumption for heating and electricity - that is, on an annual basis, homes that produce as much energy as they use, using a range of measures such as passive solar, and energy efficient design, construction and appliances with commercially available renewable energy systems. The initiative also targets a reduced consumption of other key resources including land, water, building materials, natural habitat and infrastructure.

This is an exciting initiative for CMHC as it is an opportunity for us to contribute to the broad-scale, long-term development of affordable, and sustainable housing and communities across the country and helps Canada meet its goal of reducing green house gas (GHG) emissions.

For additional information, please refer to the news release and backgrounder or contact Thomas Green, Senior Researcher, National Office, at (613) 748-2340.

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## Minister Announces Funding for Sustainable Housing

**WATERLOO, July 20, 2005 —** The Honourable Joe Fontana, Minister of Labour and Housing, through Canada Mortgage and Housing Corporation (CMHC) announced today a contribution of $1 million to launch the first phase of a Canadian net zero energy healthy housing initiative, a government/industry partnership to build a vision for a clean energy future and healthy communities.

"Our quality of life today, and the legacy we leave to future generations, demands fundamental change in the way in which we think about, and interact with, our environment," said Minister Fontana. "The net zero energy healthy housing initiative strengthens the Government of Canada's commitment to building safe, healthy, and sustainable communities."

The initial funding has been identified for the start of this initiative, which would see net zero energy home demonstrations being integrated into sustainably planned communities across Canada within 18 months. This first phase is part of the plan for a

community-scale demonstration of 1,500 homes involving all provinces and territories to be started within five years under this initiative.

"This announcement represents an important signal to industry that sustainable housing and renewable energy technologies will play an important role in our communities in the future", said Milfred Hammerbacher, Chair of the Net Zero Energy Home Coalition and member of the Canadian Solar Industries Association. The Net Zero Energy Home Coalition consists of private and public sector organizations that support the vision of a housing future where all new homes will be built to net zero energy healthy housing standards by 2030.

The goal of net zero is to implement a range of measures that will ultimately lead to housing that has a zero net consumption of energy on an annual basis for heating and electricity. The initiative will also target reduced consumption of other key resources such as land, water, building materials, natural habitat and infrastructure through application of the healthy housing principles. The net zero energy healthy housing initiative is designed to help reduce the energy intensity of Canada's housing sector, support the growing renewable energy and sustainable housing industries, and help Canada meet its goal of reducing green house gas (GHG) emissions.

"Moving towards zero energy housing is an important step towards building a sustainable living environment in Canada," said Environment Minister Stéphane Dion. "By integrating green energy technologies with enhanced energy efficiency, the net zero program represents transformational change that will help us meet our Kyoto commitment and enhance the economic competitiveness of our building sector."

Zero energy housing is a key target of long-term Government of Canada energy technology research and development. This initiative provides the potential for early application and proof of how zero energy housing solutions can work, in order to help overcome barriers to adoption and accelerate broader acceptance of this type of housing.

The ultimate objective of the net zero housing initiative is to build capacity for the broad-scale, long-term development of affordable, sustainable housing and communities in all regions of Canada. This initiative is another part of Project Green — the federal government's broader environmental vision aimed at supporting a healthy environment and a competitive economy.

Housing is responsible for 17 per cent of secondary energy use in Canada and 16 per cent of our greenhouse gas emissions.

Canada Mortgage and Housing Corporation (CMHC) is Canada's national housing agency. For over half a century, CMHC has been contributing to improving the living conditions and the well-being of Canadians through four areas of housing activities — housing finance, assisted housing, research and information transfer, and export promotion. CMHC is committed to helping Canadians access a wide choice of quality, affordable homes, and making vibrant and sustainable communities a reality across the country.

## Backgrounder
## Net Zero Energy Healthy Housing

The key objective for creating a national net zero energy healthy housing demonstration and implementation initiative is to advance new Canadian housing towards a net zero energy consumption goal.

Net zero energy healthy housing follows CMHC's five healthy housing principles (occupant comfort, energy efficiency, resource conservation, environmental impact, and affordability) by combining passive solar, energy efficient design, construction and appliances with commercially available renewable energy systems. The project will adopt the integration of renewable energy technologies such as photovoltaics, solar thermal, ground source heat etc.

The initiative also involves important improvements to community and building design, regulations, and innovative financing, such as direct lending, in support of sustainable housing and healthy cities.

Being industry led, key stakeholders (Net Zero Energy Home Coalition, Canadian solar and renewable energy industries, developers, manufacturers, homebuilders, architects, engineers, integrated design experts, researchers and federal, provincial, territorial and municipal government departments) will be contributing financially and to the project's creation, development, and deployment. The initiative will include all housing types (single detached to multi-units) and ultimately address the existing housing stock.

Looking to Kyoto and beyond, net zero energy healthy housing represents an integrated government/industry/consumer solution to address Canadian environmental quality and climate change issues and access to quality, affordable housing. The development of net zero will also ensure Canada's inclusion in competitive international markets and our next generation of value added exports.

Canadian Nuclear Association
Association nucléaire canadienne

July 5, 2005

Mr. Neil Freeman
Director, Planning Policy and Approvals
Power System Planning
Ontario Power Authority
175 Bloor Street East
Toronto, Ontario
M4W 3R8

JUL 0 8 2005

Dear Mr. Freeman:

The Canadian Nuclear Association (CNA) commissioned the Canadian Energy Research Institute (CERI) to undertake a study, which would provide a broad overview of energy in the world, the energy environment we live in, and energy resources available to us. The enclosed report **"World Energy: The Past and Possible Futures"** is the result.

CERI is a cooperative research organization established by government and industry parties in 1975. The Institute's principal role is to undertake objective, independent studies to assist corporations and governments in making energy and energy-related decisions and policy choices.

The CNA hopes that you will find the report both interesting and helpful as you tackle Ontario's energy issues and in particular seek out advice on the supply mix for affordable baseload electricity.

Should you require additional copies for staff or members of your advisory groups or if you have any questions please feel free to contact me at (613) 237-9082.

Yours truly,

Claudia Lemieux
Director of Communications and Media Relations

Attach: 2

130 Albert Street, Suite 1610 / 130, rue Albert, pièce 1610, Ottawa ON K1P 5G4
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# Canadian Nuclear Society
# Société Nucléaire Canadienne

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AUG 24 2005

2005 August 19

Ontario Power Authority
Supply Mix Submissions
175 Bloor St. E., North Tower, Suite 606
Toronto ON
M4W 3R8

Dear Sirs,

With respect to your Call for Written Submissions on the future electricity supply mix in Ontario, the Canadian Nuclear Society (CNS) is pleased to submit the attached paper prepared in September 2004 by CNS member Dr. J.T. Rogers (Professor-Emeritus, Dept. of Mechanical and Aerospace Engineering, Carleton University), titled "Options for Coal-Fired Power Plants in Ontario".

In our view Dr. Rogers provides a useful summary of the practical pros and cons presented by each option that is currently available to the people of Ontario. Although the paper is a year old and dated in some respects, its central discussion of Ontario's future energy mix remains valid, and we hope that the OPA will find this document useful as it considers this important issue.

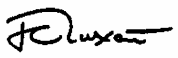
The CNS is a not-for-profit technical society dedicated to communication on issues involving Canadian nuclear science and technology. Our membership comprises over 1000 men and women engaged in one of Canada's most successful fields of high-tech research and development, design and operations, and export.

It is the CNS' position that a healthy future electricity supply mix in Ontario should retain the diversity, reliability, and environmental and economic responsibility that underpinned most of the supply expansion decisions made in Ontario in the last century.

We further believe that nuclear power will continue to play a major role in energy supply planning in this century, as the economies and populations of Ontario and Canada continue to grow and prosper. This is particularly true if external costs are included in the evaluation of all options for electricity generation.

We are grateful for this opportunity to contribute to the OPA's electricity planning process, and look forward to future participation.

Sincerely,



Dr. John Luxat
President, Canadian Nuclear Society

# OPTIONS FOR COAL-FIRED POWER PLANTS IN ONTARIO

**September 2004**

**J.T.ROGERS, PhD**
**Professor-Emeritus**
**Dept. of Mechanical and Aerospace Engineering**
**Carleton University**
**Ottawa, Ontario**

## 1.0 INTRODUCTION

The Ontario Government has announced its intention to phase out the burning of coal for electricity production in Ontario by 2007 because of the resulting air pollution [1]. Coal-fired power plants, with an installed capacity of 7578 MW, supplied 36.2 TWh of electricity in 2003 [2], about 23% of Ontario's electricity [1]. Therefore, the expressed intention of the Government presents a major challenge - to avoid an electricity supply shortfall caused by taking the coal-fired power plants out of service. The challenge includes not only the replacement of the coal-fired plants but the accommodation of the forecast increase in electricity demand in Ontario of almost 9%, on a median-growth basis, from 155.1 TWh in 2003 to 168.9 TWh in 2014 and a growth in peak demand, the key to capacity needs, of about 10%, from about 24,100 MW to about 26,600 MW, over the same period [3]. The purpose of this paper is to consider options to meet this challenge. It is well beyond the scope of this paper to undertake an economic analysis of these options, but the need to take into account cost-benefit assessments in evaluating options is emphasized.

## 2.0 COAL-FIRED POWER PLANTS IN ONTARIO

### 2.1 Ontario Power Plants and Air Pollution

There are five coal-fired power plants in Ontario, as shown in Table 1, which gives data for 2003 [2], all operated by Ontario Power Generation (OPG). These plants are significant contributors to air pollution in Ontario, as discussed below in section 2.2. OPG also operates a large fossil-fuel plant, Lennox, which uses both oil and natural gas to generate electricity. As shown in Table 1, this plant typically generates only about 7% of the total OPG fossil fuel plant electricity generated in Ontario [2, 4], so that its contribution to air pollution is relatively minor, especially when burning natural gas which is used for about 70% of its generation. Electricity generated in nuclear (40% in 2003 [1]) and hydro (22% in 2003 [1]) plants in Ontario produces essentially no air pollution. A small percentage of electricity in Ontario is generated by Independent Power Producers (IPP) and by certain industries using natural-gas fired plants, small hydro plants and waste-fired (e.g., pulp waste) plants [4], making a minor contribution to air pollution in the province.

The annual capacity factors (ACF) for 2003 for the coal-fired plants given in Table 1 indicate that these plants are used mainly for intermediate-load service[1]. Nevertheless, some of these plants, particularly Nanticoke and Lambton, have been used in recent years partly in base-load service to compensate for the loss of base-load capacity resulting from the lay-up for refurbishment of the Pickering-A and Bruce-A nuclear units [4]. With the return to service of Bruce units 3 and 4 and Pickering unit 4 in 2003 and the recently announced intention of OPG to refurbish and return to service Pickering unit 1, as recommended by the OPG Review Committee [5], the need for the coal-plants to act as base-load plants will be reduced, thus reducing emissions of air pollutants.

The Lakeview plant, scheduled for shutdown in 2005, now plays an important role because of its proximity to Toronto by supporting system reliability and providing reactive support to maintain local voltages [4]. The Thunder Bay and Atikokan plants provide local generation in Northern Ontario for voltage support and transmission security [4]. See reference [6] for a discussion of the need to maintain voltage support in transmission systems.

TABLE 1

ONTARIO POWER GENERATION FOSSIL FUEL POWER PLANTS

Data for 2003 [2] ACF: Annual Capacity Factor, %

| Station | Fuel | No. of Units | Capacity, MW | Energy, TWh | ACF, 2003 | Dates In Service | Original Retirement Date |
|---|---|---|---|---|---|---|---|
| Nanticoke | Coal | 8 | 3938 | 20.4 | 59.1 | 1973/1978 | 2015 |
| Lambton | Coal | 4 | 1975 | 10.6 | 61.2 | 1969/1970 | 2010-2020 |
| Lakeview | Coal | 4 | 1140 | 2.8 | 28.0 | 1962/1969 | 2005 |
| Thunder Bay | Coal | 2 | 310 | 1.5 | 55.2 | 1981/1982 | 2021 |
| Atikokan | Coal | 1 | 215 | 0.9 | 47.8 | 1985 | 2025 |
| TOTAL | Coal | 19 | 7578 | 36.2 | 54.3 | | |
| Lennox | Oil/Gas | 4 | 2140 | 2.8 | 14.9 | 1976/1977 | 2016 |

### 2.2 Emissions of Air Pollutants

The key air pollutants in Ontario are nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), fine (respirable) particulate matter, PM, volatile organic compounds (VOC), carbon monoxide and mercury [7, 8]. Both $NO_x$ and VOC lead to the formation of ozone, one major component of smog, while particulate matter is the other major component. Smog and $SO_2$ can irritate the lungs and lower one's resistance to respiratory infection as well as aggravating cardio-vascular

[1] Base Load: capacity required to meet relatively constant demand, i.e. the minimum demand on a utility. Peak Load: capacity required to meet intermittent high demands. Intermediate Load: capacity required above base but below peak demands, e.g., capacity needed during the day, but not at night, or during the week, but not on weekends.

disease. Mercury can cause cancer and reproductive and developmental effects; the main concern with mercury is that it can accumulate in the food chain, causing exposures significantly higher than those directly from the air [8]. The main source of carbon monoxide, which is fatal in high concentrations, is incomplete combustion in vehicles and other transportation sources [8].

The Ontario Medical Association (OMA) has estimated that approximately 1,900 premature deaths in the year 2000 may be attributed to the effects of air pollution in Ontario. Also, the OMA has estimated that, annually, about 9,800 people are admitted to hospital and some 13,000 people make emergency room visits due to the effects of air pollution in Ontario [7].

In addition to negative health effects, $NO_x$ and $SO_2$ cause acid rain which can damage lakes, vegetation and structures [8].

Of the total production of the most significant of these air pollutants in Ontario in 2000, OPG fossil-fuel power plants produced about 14.7% of the $NO_x$, 23.7 % of the $SO_2$ , 22.6% of the mercury and essentially none of the VOC and carbon monoxide [8]. (Information on the percentage of fine particulate matter produced from fossil-fuel power plants in Ontario is not provided in reference 8) Thus, phasing out of the coal-fired power plants will certainly not eliminate these air pollutants in Ontario, particularly since about 50% of air pollution in Ontario comes from sources in the US mid-west, including coal-fired plants which contribute a much larger percentage of electricity in that region than coal-fired plants do in Ontario [7, 8]. This fact should be taken into account in examining options for the coal-fired plants in Ontario.

The issue of the emission of $CO_2$, a greenhouse gas, from the coal-fired plants is not addressed in this paper, since $CO_2$ , as a natural constituent of the atmosphere, does not contribute to the negative health effects of the emissions which are the primary cause of the decision to shutdown the coal-fired plants.

### 2.3 Possible Options to Reduce Air Pollution from Coal-Fired Plants

As pointed out in section 1.0, simply shutting down the coal-fired plants in Ontario by 2007 to reduce air pollution without taking any other action is not really an acceptable option. Nevertheless, there are a number of options that could reduce air pollution from coal-fired power plants in Ontario. These options comprise:

- Improve emission controls in the coal-fired plants,
- Convert the coal-fired plants to burn natural gas or build new gas-fired plants to replace the coal-fired plants,
- Replace at least some of the coal-fired generation by new renewable (alternative) energy sources,
- Reduce need for the coal-fired plants by greater importation of electricity,

- Replace the coal-fired plants by nuclear plants.

It should be recognized that the Manley Report [5], suggested that the Ontario government should consider improving emission controls on some of the coal-fired plants and converting others to gas firing as options to shutting them down. However, the Report did not make a recommendation to this effect.

Conservation, including the use of more efficient electrical systems and appliances, the adoption of time-of-use metering [3] and what is more properly termed improvement in the effectiveness of energy use [9], can delay the need for adding additional capacity by reducing the growth of electricity demand with any of these options. However, the 10-year forecast by the Independent Electricity Market Operator (IMO) already takes into account the effects of projected conservation, based on recent and proposed actions, on the growth rate of electricity demand in Ontario [3]. Thus, conservation alone is not really a separate option for reduction of air pollution from coal-fired plants in Ontario, although it will assist all of the options by reducing demand to some extent. See section 4.0 for a discussion of an initiative of the Ontario Ministry of Energy in this area.

In assessing these options, their costs of implementation and other factors should be taken into account as well as their benefits in the reduction of adverse health effects. An effective approach for doing so is the application of the ALARA and "De Minimis" principles as applied in the regulation of nuclear activities in Canada and elsewhere [10, 11]. The ALARA (As Low as Reasonably Achievable) principle means that economic and social factors are to be taken into account in setting limits for risk or exposure to adverse health effects on a societal basis, while ensuring that individuals are protected by specific legal requirements. The "De Minimis" principle states that risks of an activity need not be reduced below a level that is generally accepted as being of no significance to an individual or to a society. That is, risks need not be reduced below a level at which efforts to control the sources of risks would constitute an undue expenditure of societal resources for an insignificant benefit in health protection.

The following sections discuss the above-listed options and draw certain conclusions.

## 3.0 IMPROVEMENT OF EMISSION CONTROLS AT COAL-FIRED POWER PLANTS

Emissions of air pollutants from coal-fired power plants can be significantly reduced by the application of emission control devices and procedures.

Emissions of $NO_x$ can be reduced by:

- improved combustion processes (low $NO_x$ burners, fluidized-bed combustion) that lower combustion temperatures to minimize $NO_x$ formation [12],

- computer controls of the combustion process (CCC) to minimize $NO_x$ formation,
- the application of Selective Catalytic Reducers (SCR) to remove $NO_x$ from flue gases,

Emissions of $SO_2$ can be reduced by:

- burning low-sulfur coal to reduce $SO_2$ formation,
- the application of Flue Gas Desulfurizers (FGD) using wet limestone scrubbing to remove $SO_2$ from flue gases [12],
- fluidized-bed combustion using limestone injection to remove $SO_2$ during combustion [12].

Emissions of particulate matter can be reduced by:

- burning low-ash coal to reduce PM formation,
- the application of Electrostatic Precipitators to remove PM from flue gases [12],
- the application of bag-house filters to remove PM from flue gases.

There is no technology currently in place for the removal of mercury from power plant emissions, although bag-house filters apparently can do so to some extent, as well as removing particulate matter [13]. However, it should be noted that a recent study has shown that mercury in soils in the USA (and its subsequent accumulation in the food chain) cannot be attributed to deposition from air of mercury emissions from fossil fuel plants and other human activities [14], so that the need to remove mercury from power plant emissions may not be as urgent as currently believed.

At one time, particularly in the UK, tall stacks at fossil-fuel power plants were considered an adequate means of controlling human exposure to air pollutants from these plants. However tall stacks obviously do not reduce air-pollutant emissions but simply reduce ground-level concentrations by dispersing the pollutants widely [12].

Emission control devices installed and procedures used at the OPG coal-fired plants are listed in Table 2. Electrostatic precipitators and low-sulfur coal are in use in all of the units at all five OPG coal-fired power plants and computer combustion controls and low $NO_x$ burners are in use in all of the units at the three large plants. Flue gas desulfurizers are installed in only two units at the Lambton plant and selective catalytic reducers, which have just come into operation this summer, are installed in only two of the eight units at the Nanticoke and Lambton plants.

TABLE 2

EMISSION CONTROL DEVICES AND PROCEDURES AT OPG COAL-FIRED PLANTS

Information from References 2, 4, 13, 15

| Plant & Total Units | Elect. Precip. | Low S Coal | CCC | Low $NO_x$ Burners | FGD | SCR |
|---|---|---|---|---|---|---|
| Nanticoke/8 | 8 units | 8 units | 8 units | 8 units | None | 2 units |
| Lambton/8 | 8 units | 8 units | 8 units | 8 units | 2 units | 2 units |
| Lakeview/4 | 2 units | 4 units | 4 units | 4 units | None | None |
| Thunder Bay/2 | 2 units | 2 units | None | None | None | None |
| Atikokan/1 | 1 unit | 1 unit | None | 1 unit | None | None |

Nevertheless, the use of electrostatic precipitators, low sulfur coal, combustion computer control and low $NO_x$ burners at the three large coal-fired stations and the use of electrostatic precipitators and low sulfur coal at the two small stations plus low $NO_x$ burners at Atikokan have reduced emissions from previous levels. Total emissions from these plants have been reduced considerably since the early 1980s with $NO_x$ emissions being reduced by about 36% from 1983 to 1999 [4] and about a further 23% from 1999 to 2003 [2] and with $SO_2$ emissions being reduced by about 68% from 1983 to 1999 [4], although increasing somewhat since then [4]. Under 1999 Ontario regulations, OPG must meet annual aggregate caps of 60 Gg of $NO_x$ emissions and 175 Gg of $SO_2$ emissions from its fossil-fuel stations, including Lennox and , under additional 2001 regulations, OPG has been limited to 35 Gg of $NO_x$ and 153.5 Gg of $SO_2$ emissions in 2002 and 2003 [2].

As indicated in Table 2, further reductions in emissions of $NO_x$ and $SO_2$ from OPG's coal-fired stations would be possible by the installation of SCRs and FGDs at those units now without them. For example, the installation of SCRs at the six units without them at Nanticoke would reduce specific $NO_x$ emissions[2] from 1.50 kg/MWh to 0.37 kg/MWh [13] and the installation of FGDs at all 8 units would reduce specific $SO_2$ emissions from 4.15 kg/MWh to 0.77 kg/MWh [13]. Assuming an annual capacity factor of 65%, as in reference 13, and assuming that the specific emission coefficients for units with and without SCRs and FGDs for Nanticoke apply also at Lambton, the annual emissions of $NO_x$ and $SO_2$ from Nanticoke and Lambton and the total from both stations are shown in Table 3. The installation of FGDs would also help to reduce PM emissions and the installation of baghouse filters would further reduce PM emissions [13].

[2] Evaluated as $NO_2$

TABLE 3

$NO_X$ AND $SO_2$ EMISSIONS AT NANTICOKE AND LAMBTON STATIONS

Assumed Annual Capacity Factor = 65%

| | $NO_x$, Gg/a Current | $NO_x$, Gg/a 8 SCRs | $SO_2$, Gg/a Current | $SO_2$, Gg/a 8 FGDs |
|---|---|---|---|---|
| Nanticoke | 33.6 | 8.3 | 93.1 | 17.3 |
| Lambton | 16.9 | 4.2 | 37.1 | 8.7 |
| Total | 50.5 | 12.5 | 130.2 | 26.0 |

Table 3 shows that the application of SCRs and FGDs to all the units at Nanticoke and Lambton would reduce the total emissions of $NO_x$ and $SO_2$ to about 12.5 and 26 Gg per year, which would contribute significantly to ensuring that total OPG emissions would be kept well below the aggregate caps specified by current Ontario regulations.

From the experience of installing the existing SCRs at Nanticoke and Lambton and the existing FGDs at Lambton, it appears that it would be possible to complete the installation of SCRs and FGDs at these stations by the end of 2007, if the commitment to do so were made now.

However, the cost effectiveness of such steps compared to other options must be assessed. For example, the installation of SCRs at two units at Nanticoke and two units at Lambton cost approximately $262 million [2] and the installation of two FGDs at Lambton in the mid 1990s cost about $500 million [2], so that the installation of these technologies at the remaining units at Nanticoke and Lambton would involve expenditures of the order of $4.3 billion. A somewhat lower expenditure estimate, $3.0 billion, for such an installation results from data provided in reference 13. These rough estimates should be compared to the costs of other options discussed later. In doing so it should be recognized that closing the coal-fired plants in 2007 will result in a write-off of valuable assets, considering the original retirement dates shown in Table 1. OPG has already shown a debit of $576 million in its 2003 financial statements to account for this loss of assets [2].

## 4.0 REPLACEMENT OF COAL-FIRED GENERATION BY NATURAL GAS-FIRED GENERATION

### 4.1 Current Commitments and Plans

OPG is a partner, together with ATCO Power Canada and ATCO Resources, in the Brighton Beach Venture: a 580 MW combined-cycle gas turbine (CCGT) plant burning natural gas, located at the old J.C.Keith power plant site near Windsor, Ontario [1]. Construction began in 2002 and the plant is scheduled to be in service in the summer of 2004, at a projected capital cost of $403 million, or about $700/kW, which is now expected to be exceeded [1].

OPG is also a partner, with TransCanada Energy Ltd, in the Portlands Energy Centre Venture, the assessment of the viability of a natural-gas fuelled energy centre in the port area of downtown Toronto. The Centre would comprise a 550 MW combined-cycle gas turbine facility and a co-generation facility which would provide steam for district heating [1]. An Environmental Review report was submitted to the Ministry of Environment in November, 2003 [1].

Assuming that the Portlands Energy Centre materializes, these ventures would provide about 1130 MW of capacity which would be in service before 2007, offsetting about 15% of the coal-fired capacity to be phased out by that date. While this capacity is just about equal to that of the Lakeview plant near Toronto it would not be available next year, when the Lakeview plant is scheduled for shutdown. Nevertheless, the locations of these plants, in Toronto and Windsor, meets an important requirement of the Independent Electricity Market Operator since, with few exceptions, replacement capacity must be located in same general area as the plant being closed, as well as having similar operating characteristics, to avoid system operability and transmission inadequacy problems [3]. See section 4.3 for further discussion of the Lakeview plant.

Finally, a small addition to Ontario capacity is being built by Northlands Power, a 25 MW gas-fired plant near Kirkland Lake [3].

### 4.2 Ontario Ministry of Energy Initiative

In partial response to the need to find replacements for the coal-fired plants that are to be phased out by 2007, the Ontario Ministry of Energy (OME) has issued a request for qualifications and interests to provide 2500 MW of new "clean" generation capacity or demand reduction measures [16, 17]. Based on responses to this request, a request for proposals (RFP) will be issued by about the end of September, 2004.

To be eligible under this RFP, proposals for new capacity, for either base, intermediate or peak generation, must:

- have a capacity of 5 MW or greater,
- not burn coal or oil as a fuel,
- not be an upgrade or expansion of an existing generating facility,
- be located in Ontario,
- be in commercial operation no later than June 1, 2009.

It is somewhat surprising to note that the date for the start of commercial operation is June 1, 2009. The RFP is implicitly recognizing that the target date for the shut down of the coal plants of the end of 2007 will not be met.

The new capacity may be connected to the IMO grid, to a local distribution network or supply electricity directly to the user. Note that there is no requirement that a proposed new plant must be located in the same general area as one of the plants to be closed, contrary to the preference

of the IMO, as stated above in section 4.1. This requirement is particularly important for the planned closure of the Atikokan and Thunder Bay coal-fired plants, which play important roles in providing generation in the north-western part of Ontario.

While small hydro developments would be eligible under this RFP[3], it is probable that most proposals would be for natural-gas fired capacity, as implied in reference 17. The RFP document also states that proposed facilities should be suitable for intermediate-load service, as were the coal-fired plants historically, and should be capable of cycling on and off overnight and of ramping to meet load changes. The RFP document also states that proposals for facilities for peaking service are unlikely to be accepted. In addition, a condition of the RFP for a specified heat rate[4] for the proposed facilities of 7500 BTU/kWh (7912 kJ/kWh), or a thermodynamic efficiency of 45.5%, will essentially limit them to combined-cycle gas turbines or CCGTs plus co-generation plants, effectively excluding lower-efficiency plants such as steam plants burning natural gas or simple-cycle gas turbines

Requirements are also specified for proposals for demand reduction measures, including a requirement to be in effect by the end of 2007.

If the objective of this RFP is met, about one-third of the current coal-fired capacity would be replaced by new capacity or demand reduction measures within the period between the end of 2007 and June 1, 2009. Thus, other measures would still be necessary to enable the phase-out of all OPG coal-fired plants by the target dates.

### 4.3 Conversion of Coal-Fired Plants to Natural Gas

The requirement that a proposed facility under the Ontario Ministry of Energy RFP not be an upgrade or extension of an existing facility appears to rule out consideration of converting the existing coal-fired plants to natural-gas firing. However, such conversions certainly should be considered as a means of ensuring that replacements are in service when the coal-fired capacity is phased out.

It appears that the only really practical means of converting to natural gas fuel would be to modify the furnace of a coal-fired unit to burn natural gas instead of coal to produce steam in its steam generators. While this step would result in relatively low thermodynamic efficiency, about 30%, or a heat rate of about 12,000 kJ/kWh, it would enable most of the components of the coal-fired plant to be retained, with only the scrapping of the coal and ash handling equipment being required, and their replacement by gas burners and any needed modifications to the furnaces. Conversion of the coal-fired plants to simple-cycle or combined-cycle gas turbine plants would involve scrapping most of the existing components at the plants and replacing them with the appropriate components for the gas-turbine cycles. It appears that it

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[3] The Ontario Ministry of Energy has also issued a request for expressions of interest for the provision of 300 MW of renewable energy capacity [16, 17, 18], as discussed in section 5.0 of this paper.

[4] The heat rate is the ratio of energy provided by the fuel to the kilowatt-hour electrical output, expressed in terms of BTU/kWh or kJ/kWh. Accounting for proper units, the heat rate is inversely proportional to the thermodynamic cycle efficiency.

would be more practical to build entirely new gas-turbine plants to replace the existing coal-fired plants rather than converting them..

The Nanticoke Conversion Study of 2001 provides information on the possibility of building of a combined-cycle gas turbine plant to replace the Nanticoke coal-burning plant [13]. The estimated capital cost of a CCGT plant plus gas pipeline connections is about $814/kW in 2001 Canadian dollars for a total capital cost for the replacement plant of $3.20 billion. The study also found that the present value of the capital cost of a CCGT for Nanticoke and of operating it to 2030 would be about $5.3 billion greater than the present value of the current Nanticoke with SCRs, FGDs and baghouse filters installed on every unit and operating the plant to the same year [13].

While conversion of all the present coal-fired capacity to more efficient simple or combined cycle gas turbines may not be very practical, for the reasons given above, the Lakeview plant presents a special case for the simpler conversion to gas firing of its furnaces. As mentioned in section 2.1, the 1140 MW Lakeview plant, scheduled to be closed in 2005, plays an important role in maintaining system reliability and sustaining local voltages by its proximity to Toronto. To enable Lakeview to continue to fulfill these important functions, its conversion to the burning of gas to generate steam for its turbines, at a heat rate of about 12,000 kJ/kWh compared to a typical current heat rate of about 10,800 kJ/kWh [4], might be worth consideration, rather than simply closing it next year[5].

## 4.4 Natural Gas Availability and Cost Issues

Replacement of coal-fired generation by gas-fired generation in Ontario, raises at least two issues of importance: the supply of natural gas for this purpose and the effect of long-term natural gas costs on electricity costs. These issues are discussed in this section of this paper.

### 4.4.1 Natural Gas Availability

An upper limit to the increased demand for natural gas in Ontario can be estimated by assuming that all the OPG coal-fired plants would be converted to, or replaced by, gas-fired plants and by making certain additional assumptions. As stated earlier, the coal-fired plants have been and are mainly used for intermediate-load service and it can be assumed that gas-fired plants will also be used for such service, as indicated by the RFP of the OME described in section 4.2. Therefore, assume that the gas-fired plants would operate at an average annual capacity factor of 60%.

[5] The Independent Electricity Market Operator had directed OPG to retain the option to convert two of the Lakeview units to synchronous condenser operation [3] but this directive was later rescinded. See reference [6] for information on this role.

As discussed in section 4.3, coal-fired plants could be converted to gas-fired plants or the coal-fired plants could be replaced by simple-cycle gas turbines or combined-cycle gas turbines[6]. Typical thermodynamic cycle efficiencies (heat rates) for these plants are:

- Gas-fired steam plants: 30% (HR:12,000 kJ/kWh)
- Simple-cycle gas turbine plants [19]: 30% to 35% (HR: 12,000 to 10,286 kJ/kWh)
- Combined-cycle gas turbine plants[19]: 45% to 50% (HR: 8,000 to 7,200 kJ/kWh)

Choosing an average cycle efficiency of 40%, or a heat rate of 9000 kJ/kWh, with the assumed annual capacity factor of 60%, and based on the thermodynamic properties of methane, the quantity of natural gas required to replace all the OPG coal-fired plants with gas-fired plants would be about $9.82 \times 10^9$ cubic metres, or 347 billion cubic feet (Bcf), per year. The total primary demand for natural gas in Ontario in recent years has averaged about 986 Bcf /yr [21, 22]. Therefore, to replace all the OPG coal-fired plants with natural gas-fired plants would require an increase of Ontario's primary demand for natural gas by about 35%, all by pipeline from Alberta. TransCanada's Canadian Mainline design capacity to Ontario is now about 1370 Bcf/yr [23] so that an excess capacity of about 384 Bcf/yr exists now. Therefore, converting all of the OPG coal-fired plants to natural gas would require almost all of this excess capacity.

Although complete replacement of the OPG coal-fired plants by gas-fired plants by the target date of 2007 (or even 2009) may not be realistic, partial replacement is certainly possible. The quantities of natural gas required to meet the needs of the cases discussed in section 4.3 can be estimated by making assumptions about annual capacity factor and heat rate appropriate to the particular case. The results are shown in Table 4, together with the above estimate for complete replacement of coal-fired generation by natural gas-fired generation. For the Ontario Ministry of Energy RFP case, it is assumed that 80% the total 2500 MW of new capacity or demand reduction is met by gas-fired projects.

For the committed or planned cases discussed in section 4.3, cases 1 to 4, Table 4 shows that the total additional annual natural gas requirements would be 114.5 Bcf/yr, or about 12.6 % of Ontario's present primary demand. This still represents a significant increase of natural gas demand over the next few years, on top of increasing demands for other uses. Table 4 also shows the additional incremental and total gas supplies needed should the Nanticoke and Lakeview conversions discussed above be implemented so as to ensure that all of the present coal-fired capacity is replaced by natural gas-fired capacity as well as to allow for some growth in intermediate load in the next five years. The resulting total gas requirements would be 339.7 Bcf/yr, or again about 35% of the present Ontario consumption. It is not clear that such an increase in capacity over the next three years, or even five years, could be realistically accommodated in the existing gas transmission system. Considering the forecast increase of demand for natural gas for all purposes in Ontario in the next few years [24], additional

[6] Cogeneration plants that combine electricity production with the provis ion of heat for industrial, district heating or other industrial purposes are very effective in their employment of energy [9, 20] and are sometimes credited with high cycle efficiencies (low heat rates) because of this [17]. However, this high efficiency, or low heat rate, does not apply to their electricity generation function and therefore is not relevant for this analysis.

pipeline capacity would be needed much sooner than previously anticipated if the OPG coal-fired plants are to be converted to gas by the end of 2007, the desired date for closing down the coal-fired stations, or even by June 1, 2009, as implied by the OME RFP.

TABLE 4

NATURAL GAS REQUIREMENTS AND COSTS FOR VARIOUS GAS-FIRED GENERATION CASES FOR ONTARIO

| Case | | Capacity, MW | Assumed ACF, % | Assumed Heat Rate, kJ/kWh | Gas Required Bcf/a | Gas Required % Ontario Present Total | Gas UEC, Cents/kWh | Annual Gas Cost, $ Billions |
|---|---|---|---|---|---|---|---|---|
| | Total Capacity | 7578 | 60 | 9,000 | 347 | 35.2 | 4.95 | 1.97 |
| 1 | Brighton Beach | 580 | 60 | 6,500 | 19.2 | 2.0 | 3.58 | 0.109 |
| 2 | Portlands | 550 | 60 | 6,500 | 18.2 | 1.8 | 3.58 | 0.103 |
| 3 | Northlands | 25 | 60 | 6,500 | 0.83 | 0.08 | 3.58 | 0.005 |
| 4 | OME RFP | 2000 [7] | 60 | 7,500 | 76.3 | 8.7 | 4.13 | 0.434 |
| | Total, 1 to 4 | 3155 | | | 114.5 | 12.6 | | 0.651 |
| 5 | Lakeview Conversion | 1140 | 60 | 12,000 | 69.6 | 7.0 | 6.60 | 0.395 |
| 6 | Nanticoke Conversion to CCGT | 3920 | 65 | 7,200 | 155.6 [8] | 15.7 | 3.96 | 0.884 |
| Total, 1 to 6 | | 8340 | | | 339.7 | 35.3 | | 1.93 |

In addition to the issue of pipeline constraints to large increases in gas supply in the short term, there is the longer-term issue of adequate gas supply over the lifetime of the gas-fired plants. Although the production rate of natural gas from conventional sources in western Canada is flat at this time, in spite of significant drilling, projections indicate that the availability of natural gas in Canada from all sources, including gas from the Arctic, the east coast and liquefied natural gas imports, will increase in the future [24]. However, there will be increasing

[7] Assuming 80% of OME RFP proposals will be for natural gas-fired plants.
[8] According to The Nanticoke Conversion Study, the gas requirement for the CCGT plant would be 162 PJ/a [13]. For a gas heating value of 1000 BTU/cf [13], this is equivalent to 153.6 Bcf/a, in excellent agreement with the present estimate.

demands for gas exports, for oil-sands recovery and upgrading and other purposes [24], which could jeopardize the reliable supply of gas for electricity generation in Ontario.

### 4.4.2 Natural Gas Cost

Replacement of coal-fired generation in Ontario by gas-fired generation will increase significantly the unit energy costs of electricity and the total annual fuel costs for these plants . Current natural gas prices in Canada are about $7/GJ [24, 25] and natural gas prices are expected to average somewhat above $5/GJ for the next ten years [24]. Assuming an average gas cost of $5.50/GJ and the heat rates given in Table 4, the current gas unit energy cost (UEC) in cents per kilowatt hour for the cases considered in section 4.4.1 can be calculated and are also given in Table 4. From this value, the total annual current cost of gas for these cases can also be calculated for the given capacities and capacity factors, as also given in Table 4.

Thus, the replacement of coal-fired generation by the committed or planned natural gas fired generation would increase fuel costs for these plants by a factor of about 2.5. Also, it should be noted that the fuel UEC for the committed or planned gas-fired generation, about 3.6 to 4.1 cents/kWh, is a significant fraction of the capped price of electricity for low-volume residential and other designated users in Ontario of 4.7 cents/kWh [26], meaning that this electricity will most probably be sold at a loss, once other operating and maintenance costs as well as capital-costs recovery are taken into account. Considering the increased future demands for natural gas as mentioned in section 4.4.1, there could very well be significant price increases and volatility even with the additional sources of supply. Thus, the costs of electricity from gas-fired power plants in Ontario could be even higher than estimated here

For comparison, assuming a current coal cost in Ontario of about $46 per tonne [13], assuming a higher heating value of 12,000 Btu/lb (27,900 kJ/kg) for the coal, the present UEC and total annual cost for the OPG coal plants can be calculated to be about 1.49 cents/kWh and about $0.60 billion, respectively. .

## 5.0 REPLACEMENT OF COAL-FIRED GENERATION BY NEW RENEWABLE (ALTERNATIVE) ENERGY SOURCES

### 5.1 Current Situation

First of all, the meaning of "renewable energy sources" must be clarified. The Ontario Ministry of Energy RFP effectively excludes large-scale hydro power plants [17], which provided about 37,000 GWh, or about 23%, of electricity in Ontario in 2003 [27]. In any case, there are no remaining large-scale hydro sites in Ontario that can be readily developed economically, although the Ontario Water Power association estimates that a potential of 1200 MW to 4000 MW of hydro capacity could perhaps be added [1]. Only small hydro plants, 100 MW or less, are considered "renewable energy sources" for the present purposes [17]. Thus, a more appropriate term, "alternative energy sources", is often used.

Nevertheless, a limited expansion of conventional hydro power has been committed in Ontario. The construction of an additional water tunnel at the Adam Beck hydro plant on the Niagara river will add about 200 MW capacity and provide about 1.6 TWh per year of electricity[9] [28]. However, this expansion will take about 4 ½ years to complete and so will not be available by the end of 2007, when the coal-fired plants are to be closed, but should be available by about the same target date as that of the new clean generation called for by the OME RFP [17].

At present, sources classified as renewable energy sources provide only about 1% of Ontario's electricity, 1835 GWh per year, with about 90% of this energy, 1635 GWh/yr, from wood and pulp mill waste and only about 10%, 180 GWh per year, or 0.1% of the total, from wind [27].

As noted in section 4.2, the Ontario Ministry of Energy issued, on April 28, 2004, a request for expressions of interest and qualifications for the provision of 300 MW of renewable energy sources of electricity [16, 17, 18], as a step towards meeting targets of 1350 MW by 2007 and 2700 MW by 2010. Specified as renewable energy sources in this request are wind, solar, water, biomass and landfill gas. The Ministry has received 90 expressions of interest to this request with proposals totalling 4400 MW and has requested that firm proposals be submitted by August 25, 2004 [30].

## 5.2 Inherent Weaknesses of Alternative Energy Sources for Large-Scale Power Generation

Since this paper deals with options for Ontario's coal-fired plants, we need to understand the role of alternative energy sources for this purpose. This requires a recognition of the characteristics of these sources, in particular, wind and solar, which are often proposed or suggested alternatives to conventional electricity generation. Solar and wind have two inherent weaknesses for large-scale electricity production: low intensity[10] and intermittency[11]. The low intensity requires large areas to collect the energy and intermittency means that the energy is not always available when needed. The intermittency drawback can be overcome to some extent by provision for energy storage when it is feasible, but this provision may increase the area requirements for collection of energy even further. For example, an analysis has shown that the land area required for a solar-thermal electricity plant to replace the Pickering nuclear power plant near Toronto in providing base-load service, i.e., including provision for storage as thermal energy, in a typical December would be over 600 sq.km., about the size of the Toronto metropolitan area, compared to the area of the Pickering plant, 2 sq.km.[31]. The land costs for the solar plant would be astronomical and the use of so much land for a single purpose in a densely populated area would be socially disruptive.

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[9] The lack of economic sites for large-scale hydro development in Ontario is underlined by the results of a study of the feasibility of building a new 600 MW hydro power unit at the Adam Beck site which found that this proposal was uneconomic [28, 29]

[10] Since solar energy generates wind energy by differential heating of the earth's surfaces, the low intensity of wind energy results from the low intensity of solar insolation, about 1 kW/m$^2$ maximum and about 0.14 kW/m$^2$ on an average at the earth's surface in Canada [12].

[11] Biomass also has the limitation of low intensity, since its production is governed by solar energy. The intermittency deficiency is overcome by storage of solar energy by photosynthesis in the biomass. However, this process takes considerable time to provide quantities needed for large-scale power production..

While large-scale solar electricity generation has not been seriously proposed for Ontario, wind power already produces about 180 GWh/yr from an installed capacity of 110 MW [27], proposals for additional wind plants have been made and wind plants will probably contribute to the 300 MW of new renewable energy called for by the Ontario Ministry of Energy [30]. The low intensity of wind power results in a requirement for many large wind turbines to generate any significant power. Furthermore, these turbines have to be well-spaced to ensure that wake effects on adjacent turbines do not reduce blade efficiency, and thus power generation, significantly. Based on data from different sources, the power-to-area intensity for wind farms varies from about 2.8 MW/km$^2$ to about 5.0 MW/km$^2$ [32, 33, 34]. Therefore, to replace the capacity of the OPG coal plants by wind power plants, assuming an optimistic power intensity of 4 MW/km$^2$, would require a total area of about 1,900 sq.km., about three times the size of metropolitan Toronto. The cost and difficulty of assembling adequate wind sites over such an area in southern Ontario would be prohibitive, even though some of the required area would also still be usable for agricultural purposes. In addition, the total electricity produced annually by this capacity would be considerably less than that produced by the coal-fired plants because of the low annual capacity factors of the wind plants. From the above data on the current installed capacity and energy production of wind power plants in Ontario, the annual capacity factor of these plants is 18.7%, compared to about 60% to 65% for the coal-fired plants. An ACF of 18.7% is on the low side of the range of ACFs for existing wind farms, 20% to 30% [35]. Assuming an average ACF of 25%, replacing the coal-fired plants by the same capacity of wind-fired plants would result in the generation of only about 40% of the electricity produced in a year by the coal-fired plants. Furthermore, unlike power from the coal-fired plants, power from the wind plants would not be available on demand to meet varying loads, but would depend on the variability of the wind. Since there is no practical means of storing electricity directly on a large scale, building additional wind plants to overcome this intermittency would not be helpful[12].

In effect, wind plants cannot really replace the coal-fired plants, since they cannot meet the requirements of intermediate-load service, that is, being available on demand to meet varying loads over a day or other period. Similarly, wind plants cannot be used for base-load to provide continuous power or for peaking plants to provide peak power on demand. Wind generation is only useful for now as displacement energy, being accepted by the grid, when it is available, in preference to energy from conventional plants whose operating costs at that time are greater than those of the wind energy plants .

It is informative to consider why large-scale hydro plants, generating 23% of Ontario's electricity and about 58% of Canada's in 2003 [27], are not constrained by the limitations of low intensity and intermittency that affect solar and wind energy plants, in spite of being themselves renewable energy plants depending ultimately on solar energy through the hydrologic cycle. For a large-scale hydro plant, nature herself makes up for these deficiencies by collecting precipitation over a large area, the drainage area of the river on which the plant is

[12] Conceptually, wind power plants could be used with indirect storage systems, such as by providing electricity when available for a pumped hydro system or, in the future, for hydrogen production by electrolysis, but the technical and economic feasibility of such applications have not been demonstrated. In any case, they are not available now as options to the OPG coal-fired plants.

located, thus compensating for the low intensity but also smoothing out the intermittency of the precipitation over the drainage area. Nevertheless, nature generally still has to be assisted in compensating for intermittency, by the building of a dam or dams on the river to provide water storage.

A significant practical problem would arise should the fraction of electricity generated by wind in Ontario reach more than a few percent of the total as is the case in Denmark, where wind energy provides about 12% of electricity[13] in a typical year [36]. The management of the stability of the electricity grid with such a fraction of unreliable and randomly varying generation becomes very challenging.. This challenge has been described by a senior Danish utility manager as akin to attempting to manoeuvre a rapidly moving tractor-trailer with no brakes, clutch, accelerator or steering wheel [37]. Meeting this challenge in Denmark is possible mainly because of the strong interconnections between the Danish grid and the Swedish and German grids [37], which can provide reliable nuclear and coal-fired electricity to Denmark, as needed, to compensate for the variability of the winds. While this problem is not likely ever to arise in Ontario, it represents another aspect of the limitations imposed by the intermittency of supply from wind power plants.

Because of the predominance of wind energy amongst alternative energy sources, the rest of this section will deal solely with aspects of wind energy.

### 5.3 The Economics of Wind Energy

Wind plants, like hydro plants, have very low operating costs because they have no fuelling costs, only labor and maintenance costs. Unit energy costs for the recovery of capital, however, are high because of the large structures, wind turbine-generators and gearing and control components needed as well as the large land requirements. Most large-scale wind turbine-generators today have capacities in the range of about 500 kW to 2 MW, with production beginning on 3 MW units [35, 38]. The 3 MW unit will sit on a 75 metre tower and has turbine blades about 90 metres in diameter [38], so that the tips of the blades are as high as 120 metres above the ground, about the height of a 40 storey building. Smaller units still require tall towers, 50 metres for utility-scale turbines, to ensure exposure to adequate wind speeds, and large-diameter blades, typically 40 to 50 metres [35] . Thus, for a relatively small wind farm of 100 MW capacity, about 34 of the 3 MW units would be required, requiring about 25 sq. km of land. The capital cost, exclusive of land cost, for large-scale wind power plants today is about $1000/kW (US), or about $1350/kW (Can.), for land-based plants [36, 39] and about 1.5 to 2 times as much for off-shore plants, such as have been built in Denmark, the UK, Germany and elsewhere [36]. Therefore, unit energy costs for capital recovery for a land-based plant, assuming a 15% discount rate and a capacity factor of 25%, would be about 9.2 cents per kilowatt-hour, ignoring land costs. Operating and maintenance costs would add one or two cents per kWh. Thus, the real unit energy cost of wind energy would be well above the capped price to domestic and other small consumers in Ontario [26]. The subsidy provided until 2007 for wind power installations in Canada by the Canada Wind Power Production Initiative of 0.8 to 1.2 cents/kWh [40] would reduce, but not make up, this difference.

[13] The remainder is provided by coal-fired plants and by imported electricity from Sweden and Germany.

### 5.4 Wind Energy and the Environment

Wind power, like hydro power, emits essentially no air pollutants in operation and therefore is held in high regard by environmentalists and the public. Nevertheless, large-scale wind generation does result in certain environmental impacts that need to be recognized. In addition to the large surface areas required, these include:

* bird kills by the moving turbine blades, particularly at night and where wind turbines are located on migratory bird flyways [32, 41, 42],

* low-frequency noise resulting from the turbine blades passing the supporting towers, which may have adverse health effects as well as causing annoyance to those living nearby [32, 43] ,

* interference with defence radar, which has resulted in the refusal for permission to build an offshore wind farm in the UK, and with radio and television reception [32, 44],

* visual impacts of large wind farms which have resulted in opposition to wind farms in some locations, particularly in national parks [32, 45],

* potential impacts of turbine blade failure on nearby residents [32, 39] .

Siting of wind farms at well-chosen offshore sites, such as on the Great Lakes, would alleviate or overcome many of these difficulties, but at the expense of increased capital costs as noted in section 5.3. To avoid health impacts, the risk of injury and noise effects, some jurisdictions have required wind turbines to be located a minimum distance of from 500 to 1000 metres from roads or houses, generally increasing land requirements and thus costs [32, 46].

A thorough assessment of the environmental impacts of large-scale wind power developments and the pros and cons of large-scale wind power in general, in the context of a proposed wind power development in Prince Edward County, Ontario, is provided on a website maintained by a local group in that county [32]. A recent press report has summarized growing opposition in Europe to wind farms because of these environmental issues [47] and a political party has been formed in Scotland to oppose further development of wind power there [48].

These issues do not mean that wind power does not have a role to play in providing electricity in Ontario, but it must be recognized that such issues coupled with wind power's inherent deficiencies will severely limit its contribution to reliable electricity generation in this province. For example, should the target of the Ontario government to achieve 2700 MW of wind power capacity by 2010 be met, the annual electricity generation would be less than that of one of the Bruce-B nuclear units, based on typical annual capacity factors, and, unlike electricity from the Bruce-B, would not be available on a predictable schedule.

## 6.0 REPLACEMENT OF COAL-FIRED GENERATION BY INCREASED IMPORTATION OF ELECTRICITY TO ONTARIO

The Ontario grid is interconnected with three American states: Minnesota (150 MW capacity), Michigan (2450 MW capacity) and New York (2500 MW capacity, 2 connections) and two Canadian provinces: Manitoba (245 MW capacity) and Quebec (1395 MW capacity, 4 connections) [1, Fig.6b]. All these interconnections can be utilized for exports as well as imports. In 2003, Ontario was a net importer of electricity, with 2240 GWh from Quebec, 645 GWH from Manitoba and 2000 GWh from the US [27]. Early in the 1990s, Ontario was a net exporter of electricity, but the lay-up of the nuclear plants in 1997 and 1998 resulted in Ontario becoming a net importer since then [49]. While the total capacity of the interconnections is about 6600 MW, the effective capability for electricity imports to Ontario is about 4000 MW [3].

Although interconnection of the Ontario grid with US grids resulted in the Ontario power blackout of August 2003 [50, 51], interconnections in general are valuable since they improve the economics and reliability of power generation as well as reducing the need to build new capacity [1, 21]. The interconnections with the US, with utilities with a roughly similar generation mix, enable overall reductions in generating costs by taking advantage of the diversity of loads over the interconnected grids. However, the US interconnections do not provide access to any significant unused capacity that could provide firm power over a prolonged period beginning in three years and thus they cannot serve as replacements for the coal-fired plants.

The interconnections with Manitoba and Quebec could possibly provide Ontario with access to low-cost hydro power on a firm basis, assuming further development of hydro projects in those provinces, such as the Lower Churchill project, which is in Labrador but to which Quebec has access through long-term firm contracts [27].

However, energy to replace the Ontario coal-fired plants from any development in Manitoba would require a significant increase in the capacity of the interconnection from its present 245 MW capacity. Construction of larger-capacity transmission lines would be very costly, would take considerable time and would have to be based on firm commitments for new hydro development in Manitoba as well as the guarantee of long-term energy supply contracts to Ontario. Also, supply by transmission line from Manitoba would not satisfy the condition of the IMO that replacements be located in the same general area as the replaced plant and be similar in characteristics.

The interconnections with Quebec have more capacity, about 1400 MW, than that with Manitoba, and an additional 1250 MW interconnection has been proposed [27]. Nevertheless, as with Manitoba, additional transmission lines would have to be built over the next few years and firm long-term contracts would have to be available to enable the coal-fired plants to be replaced with hydro power from Quebec. Again the IMO condition for replacement power would not be satisfied.

# 7.0 REPLACEMENT OF COAL-FIRED GENERATION BY NUCLEAR GENERATION

## 7.1 Recent Additions to In-Service Nuclear Capacity

With three laid-up nuclear units, one at Pickering-A (unit 4) and two at Bruce-A (units 3 & 4), returning to service in 2003 and early 2004, Ontario's nuclear power in-service capacity has been increased by about 2015 MW [27, 52] in the last year. Addition of this nuclear base-load capacity to the Ontario grid has reduced the need for the coal-fired plants to operate as base-load plants, as they have done periodically since the Pickering-A and Bruce-A units were laid up, as mentioned in section 2.1 of this report, and thus will reduce air-pollutant emissions to some degree. Recent information from the IMO website shows that reduced operation of the coal-fired plants is already occurring because of the recently added capacity in Ontario. During the months of June, July and August, 2003, the coal-fired plants produced 9.9 TWh of electricity, while they produced 5.5 TWh during the same months in 2004, a reduction of about 45% [53].

## 7.2 Committed and Potential Additions to Nuclear Capacity

Additional nuclear generation could be provided by restarting the remaining laid-up reactor units, three at Pickering-A and two at Bruce-A. However, certain issues needed to be dealt with before these restarts could begin.

In the case of the Pickering station, the actual cost of the refurbishment of Pickering unit 4, about $1.25 billion, exceeded the estimated cost by a factor of almost three and the schedule slipped by more than two years from the original projection, so that questions arose about the economics and practicality of restarting the remaining units[14]. The Ontario government appointed a Pickering Review Panel to determine the causes of the cost and schedule overruns of the unit 4 restart [54]. The Review Panel identified the causes of the overruns and made recommendations to avoid them, should the government decide to restart the remaining units. Based on the findings and recommendations of the Review Panel and its own assessment of these, another body appointed by the government, the OPG Review Committee [5], recommended that Ontario proceed with the refurbishment of Pickering unit 1, based on two key findings: procedures to prevent the problems with unit 4 from reoccurring were in place and refurbishment of unit 1 was the least expensive and quickest means for Ontario to build needed new capacity. Based on this recommendation, the Ontario government has recently approved the return to service of Pickering unit 1 [55], which will provide an additional 515 MW of base-load capacity to the Ontario system when the refurbishment, estimated to cost about $900million[15], is completed in about 15 months, i.e., before the end of 2005. The OPG Review Committee also recommended, and the government has agreed, that OPG wait until

[14] The refurbishment of Bruce units 3 & 4 cost about $720 million and was completed within about six months of the scheduled date [52].

[15] This amount includes sunk costs of about $325 million, covering work already done on unit 1, as part of the original refurbishment project [5]. Reference 5 cites a total cost, including sunk costs, of $825 million and an in-service date of September 1, 2005 for the Pickering-1 restart.

there is clear evidence of success on the unit 1 project before proceeding with any further work on refurbishing Pickering units 2 and 3 [5].

In the case of the Bruce-A station, the cost and schedule of restarting units 1 and 2 is expected be higher than those associated with the restart of units 3 and 4 because of the need to replace the steam generators, which was not the case for units 3 and 4. Bruce Power is evaluating the case for the restart of these two units, but a decision has not yet been made [56].

However, additional nuclear capacity will be provided over the next few years by improvements at the Bruce-B units. Bruce-B capacity will be increased by about 400 MW by the use of new CANFLEX Low Void Reactivity Fuel bundle design, developed by AECL, and the installation of higher-efficiency low-pressure turbines [57]. The new-design fuel bundles have already been loaded into Bruce unit 6 and the new turbines are now being installed in that unit [57, 58].

Therefore, with the restart of Pickering-A unit 1 and the Bruce-B upgrade, additional nuclear capacity totalling about 915 MW will be available to the Ontario grid over the next few years. There is also the potential of restarting Pickering-A units 2 and 3, adding 1030 MW, and Bruce-A units 1 and 2, adding 1500 MW, for a total of 2530 MW capacity that may be added to the Ontario system. Bruce Power is also assessing the eventual refurbishment of the four Bruce-B units to extend their lifetime well into the future [56].

### 7.3 Limitations of Nuclear Generation in Replacing Coal-Fired Generation

As discussed above, about 2930 MW (1030 MW at Pickering-A, 1500 MW at Bruce-A and 400 MW at Bruce-B) of nuclear capacity will have been added to the Ontario grid from 2003 to 2007, which will reduce the need for the coal-fired plants to function as base-load plants and will thus reduce emissions of air pollutants, as is already happening as noted above [53]. This added capacity will also reduce the need to import electricity into Ontario from the US, thus indirectly reducing the concentrations of air pollutants in Ontario from emissions from coal-fired plants in the US.

Nevertheless, this added nuclear capacity would not completely displace the equivalent coal-fired plant capacity in meeting intermediate loads, i.e. in load-following over a day or a week. The nucleonic characteristics of the natural uranium CANDU core and the design of the power control systems place constraints on changes in power level [59]. Current CANDU reactors do not normally operate at steady power levels less than about 60% of full power, because reducing the power from full power to a level lower than about 60% results in the build up of fission product xenon, a strong neutron absorber, in the fuel to the extent that the control system is unable to prevent the reactor from "poisoning out", i.e., shutting down [51, 60]. Also, should a CANDU unit operating at full power be shutdown to zero power, the restart must begin within about half an hour; otherwise it cannot be brought back up to full power

until after the xenon in the fuel decays sufficiently, about 36 hours later[16]. It will then take about five hours to bring the reactor to full power from zero power. These constraints hinder nuclear plants from readily meeting intermediate loads on a regular basis.

Even if there were no physical constraints on load-following with the Ontario reactors, economic penalties will be incurred by this mode of operation. With the high capital costs of nuclear power plants compared to those of coal-fired plants, the nuclear plants must be operated at high annual capacity factors, i.e., as base-load plants, to keep unit energy costs reasonably low [12].

### 7.4 Future Need for Nuclear Generation in Ontario

The demand for electricity in Ontario is expected to grow considerably in the future. The Independent Electricity Market Operator forecasts that demand will grow by as much as 17% from now to 2014 [3] while the National Energy Board forecasts an increase of 21% by that date and by about 40% by 2025 [27]. Therefore, there is a consequent need for additional base-load capacity in Ontario to ensure that this increasing demand can be met and to ensure an adequate reserve margin. Base-load capacity requirements in Ontario are now met mainly by the nuclear plants and by the large-scale run-of river hydro plants [3]. There is little possibility of increasing large-scale hydro generation in the future in Ontario, as noted in section 5.1 and new coal-fired plants would not be acceptable. The cost of natural gas is too high and its long-term supply is too questionable to rely on CCGT plants for base-load power. The unreliability of wind power and other alternative sources preclude their use for base-load purposes.

Therefore, the only realistic option for future base-load power is to increase nuclear generation, as recognized by many knowledgeable organizations and individuals [3, 5, 27, 54, 56, 61]. The restart[17] of the remaining laid-up nuclear units at Pickering-A and at Bruce-A would just get Ontario back to where it was with nuclear capacity in the first half of the 1990s and new reactor capacity will be needed. Bruce Power is now assessing the building of new nuclear generation [56], using AECL's Advanced CANDU Reactor 700 MW (ACR-700) design, featuring considerably reduced capital costs, low operating costs and, eventually, a 36-month construction schedule [63]. The ACR should be market-ready by mid-2007 and the first two units could come on line by about 2012. A recently released study by the Canadian Energy Research Institute, confirms that nuclear power, either the ACR-700 or a CANDU-6 design, would provide the most economic base-load power for Ontario under public financing conditions, compared to a combined cycle gas turbine plant and a coal plant equipped with flue-gas desulfurizers [64].

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[16] In an emergency, Ontario nuclear plants can disconnect from the grid and continue to operate at 60% load by transferring energy to the steam generators as in normal operation, with the steam being discharged to atmosphere (Pickering-A, Pickering-B and Bruce-A) or recirculated to the condensers (Bruce-B and Darlington). For the Pickering plants and Bruce-A, this mode of operation could continue as long as de-mineralized water was available and for Bruce-B and Darlington, it could continue indefinitely. A plant can then be brought back on line as needed. The latter procedure was followed at three Bruce-B units and one Darlington unit following the power blackout of August, 2003, which enabled these units to begin producing power for the grid within a few hours after the blackout started [50, 51].

[17] The Ontario government has just announced that it is to begin negotiations to restart units 1 and 2 at Bruce [62].

As nuclear generation grows as a fraction of the total generation in Ontario, it would eventually be advantageous for nuclear units to load-follow more readily than they can now, so it would be useful for the ACR to have enhanced load-following capability. In this regard, with the projected unit capital cost of the ACR, about $1350/kW, much reduced from that of current CANDU-6 reactors, about $2200/kW, the economic penalty associated with intermediate-load operation would be less with the ACR design than with the current CANDU-6 design.

Nevertheless, nuclear generation for a number of years in the early1990s produced over 60 % of Ontario's electricity [65], so that a significant increase in nuclear's present contribution of about 40% is clearly feasible, in spite of any physical and economic limitations to the operation of nuclear power plants as intermediate-load plants.

## 8.0 CONCLUSIONS

Based on the foregoing assessments, certain conclusions can be reached on the various options for the coal-fired plants in Ontario. In reaching these conclusions, a commitment of the Ontario government about the closing of the coal-fired plants must be kept in mind: "We remain committed to replacing coal-fired electricity generation in the province. In so doing, we will never put Ontario consumers in jeopardy and will be totally satisfied that adequate alternatives are in place before we replace coal." [66] .

In reaching conclusions on these options, it should be kept in mind, as discussed in section 2, that conservation alone is not really a separate option for reduction of air pollution from coal-fired plants in Ontario, although it will assist any of the options by reducing demand to some extent.

### 8.1 Actual and Committed Additions to Ontario Intermediate Load Capacity, 2003 to 2009

From the foregoing assessment, the actual and committed additions to the Ontario grid are summarized in Table 5, which also shows the suitability of the added capacity for intermediate-load operation, as would be needed to replace the coal-fired generation.

As shown in Table 5, actual and committed additions to the Ontario grid that are fully capable of meeting intermediate loads total 3355 MW, but this capacity will only be fully available by June 1, 2009, at the earliest. In addition, additional nuclear capacity of 2930 MW will be fully available by about 2007, but there are limitations to the ability of this capacity to meet intermediate loads. The ultimate total capacity in these two categories is about 6800 MW, less than the 7578 MW capacity of the coal-fired plants, and not all of this added capacity is capable of meeting intermediate loads on a regular basis. Therefore, it is apparent that the Ontario coal-fired plants cannot be completely replaced by the actual and committed additions to the grid, and these replacements will not be completely available until the middle of 2009.

**Therefore, the Ontario coal-fired plants cannot all be shut down by 2007 if the commitment of the Ontario government that adequate alternatives will be in place before coal plants are replaced is to be fulfilled.**

TABLE 5

ACTUAL AND COMMITTED ADDITIONS TO ONTARIO CAPACITY
2003 TO 2009

| | MW, INTERMEDIATE LOAD CAPABLE? | | | |
|---|---|---|---|---|
| PROJECT | YES | PARTLY | NO | IN-SERVICE[18] |
| | | | | |
| Brighton Beach | 580 | | | 2004 |
| Portlands | 550 | | | ? |
| Northlands | 25 | | | ? |
| M of E RFP | 2000[19] | | | June 1, 2009 |
| Beck Tunnel | 200 | | | 2008 |
| Renewables | | | 300 | Dec. 31, 2007 |
| Pickering-4 | | 515 | | Sept.25, 2003 |
| Bruce-4 | | 750 | | Oct. 7, 2003 |
| Bruce-3 | | 750 | | Jan.9, 2004 |
| Pickering-1 | | 515 | | 2005 |
| Bruce-B Upgrade | | 400 | | 2007 |
| | | | | |
| Total | 3355 | 2930 | 300 | |

## 8. 2 Improvement of Emission Controls at Coal-Fired Power Plants

Table 3, in section 3, shows that the installation of selective catalytic reducers (SCR)and flue gas de-sulfurizers (FGD) at the Nanticoke and Lambton coal-fired plants, representing almost 6000 MW of capacity, about 80% of the total coal-fired capacity in Ontario, would result in significant reductions in emissions of the major air pollutants $NO_x$ and $SO_2$, with emissions of $NO_x$ being reduced to 25% and of $SO_2$ to 20% of the present amounts. Installation of this equipment at these plants would require an investment in the estimated range of $3 billion to $4.3 billion. However, maintaining these plants in operation with these emission controls added would avoid the premature write-off of valuable assets, at an annual charge of about $576 million.

[18] Date of final addition of capacity
[19] Assumes that 500 MW of the RFP request will be met by demand-reduction measures, which, as a minimum, will be balanced by demand growth.

**Before deciding to close the Nanticoke or Lambton plants in 2007, it would be prudent to undertake a cost-benefit analysis of the addition of SCRs and FGDs at least at one of these plants, taking into account health benefits resulting from the significantly reduced emissions, as suggested in the Manley Report [5]. Keeping the Nanticoke plant open by adding SCRs and FGDs would have the benefit of reducing emissions significantly while retaining over 3900 MW of intermediate-load capacity for the Ontario system, which, with the committed and planned gas-fired capacity, would provide about 7300 MW of intermediate-load capacity, almost the same as now provided by all the coal-fired plants. This step could be completed by about 2007 if the commitment were made soon and would avoid any economic penalties and operational difficulties resulting from having to operate nuclear plants as load-followers.**

### 8.3 Replacement of Coal-Fired Generation by Natural Gas-Fired Generation

It is evident from Table 5 that committed and planned natural gas-fuelled generation, about 3155 MW, will only be able to replace about 42% of the total 7578 MW of coal-fired power. The cost of replacing most of the rest of the coal-fired power with natural gas-fired power, for example by building a CCGT plant to replace Nanticoke, would be very high and would face issues of gas supply and costs over the lifetime of the gas-fired plants, as discussed in section 4.

**It is concluded that increasing the reliance on natural gas-fired generation in Ontario much beyond present commitments and plans would raise concerns about the reliability of gas supplies and would probably result in increasingly high costs of electricity generation.**

**Shutdown of the coal-fired plants at Thunder Bay and Atikokan would require replacement capacity of about 500 MW to be located in the same general areas to meet the IMO requirement for voltage support and for transmission security. Since gas transmission costs to these areas would be less than to central Ontario, gas-fired generation would be appropriate for this purpose, so that some of the proposed or future gas-fired plants should be located there.**

**As a special case, the conversion of the Lakeview plant to the burning of natural gas to generate steam for its turbines, rather than closing it in 2005, might be considered because of its important role in maintaining transmission system reliability and sustaining local voltages by its proximity to Toronto.**

### 8.4 Replacement of Coal-Fired Generation by Renewable (Alternative) Energy Sources

As made clear in section 5, wind and solar sources suffer from two inherent deficiencies for large-scale electricity production, low intensity and intermittency. The low intensity results in a requirement for very large surface areas for a given capacity. Replacement of the Ontario coal-fired capacity by wind power would require suitable sites over an area of about 1900 $km^2$, but

this capacity would produce only about 40% of that produced by the coal plants because of wind intermittency. Because of its intermittency, wind generation cannot really replace the coal plants in meeting intermediate loads, since it is not available on demand and cannot be cycled to meet changing load demands. Also, experience in Denmark shows that stability problems arise when wind power becomes more than a relatively small contributor to an electricity grid.

Because of the need for many large wind turbines for any significant generation capacity, the capital costs of wind energy are high, and the wind's intermittency means that capacity factors of wind farms are very low, only 20% to 30%. Thus, the unit energy costs for recovery of capital are very high, typically about 9 or 10 cents per kWh, well above the capped rate for small consumers in Ontario.

The operation of wind plants, while avoiding emissions of air pollutants, is not free from all environmental impacts, as described in section 5.

**It is concluded that wind energy is not a realistic option to replace the coal-fired plants and will continue to play only a very minor role in electricity generation in Ontario.**

### 8.5 Replacement of Coal-Fired Generation by Increased Importation of Electricity to Ontario

The effective capability for electricity imports into Ontario from the US, Manitoba and Quebec is now about 4000 MW, as stated in section 6. The US interconnections do not provide access to any significant unused capacity that could provide firm power over a prolonged period and thus they cannot serve as replacements for the coal-fired plants.

The interconnections with Manitoba and Quebec could possibly provide Ontario with access to low-cost hydro power on a firm basis. However, since the capacity of these interconnections is low, construction of larger-capacity transmission lines would be needed, would be very costly, would take considerable time and would have to be based on guarantees of long-term firm energy supply contracts.

**While strengthened interconnections with the US and Quebec and Manitoba would be generally beneficial, increased importation of electricity into Ontario is not a viable solution on its own for replacing coal-fired generation by the target dates.**

### 8.6 Replacement of Coal-Fired Generation by Nuclear Generation

As discussed in section 7, technical limitations constrain the operation of CANDU units as intermediate load plants and there also is an economic penalty for such operation. The economic penalty of operating at reduced load will be less for the ACR-700 design than for the CANDU-6 design.

**Almost 3000 MW of nuclear capacity will have been added to the Ontario grid in the period from 2003 to 2007, which will reduce, or even eliminate, the need for the coal-fired plants to function as base-load plants, as is already occurring, and will thus reduce emissions of air pollutants. This added capacity will also reduce the need to import electricity into Ontario from the US, thus indirectly reducing the concentrations of air pollutants in Ontario from emissions from coal-fired plants in the US.**

**Strong growth of electricity demand in Ontario is expected in the future. New base-load generation capacity will be needed soon, in addition to that which may be provided by the restart of the four remaining laid-up reactor units at Pickering and Bruce. The only realistic option for new base-load capacity in Ontario is nuclear, using either the new Advanced CANDU Reactor or the well-established CANDU-6 design**

**As the percentage of nuclear generation in Ontario grows to and beyond the level of about 60% attained in the early 1990s, the ability of CANDU reactors to operate to some degree as load followers will become more important, so enhanced ability in load following should be a design criterion for new nuclear generation in Ontario.**

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September 27, 2004

# CNWC Submissions to the OPA 26/08/05

This paper provides the view of the Canadian Nuclear Workers Council (CNWC) in regards to the current electrical supply system in Ontario and our recommendations for the future.

Introduction

The members of the CNWC, many being workers in the electrical industry in Ontario, are of the opinion that a reliable and stable supply of electricity at a reasonable costs is very important for the citizens of Ontario, as well, it is required to maintain a healthy economy for the Province. We believe immediate actions are required in order to maintain a stable electrical system in Ontario.

## Current Status of Electricity Supply in Ontario

The electricity generators in Ontario, whether they are coal, hydroelectric or nuclear, are ageing. Fortunately hydro electric stations have long lives & can be rehabilitated much easier & at a lower cost than the other forms of generation. Some of our coal generation fleet is very old & nearing the end of their design life. The nuclear units, most of which are newer than the coal generators, are also ageing. These facts all point to the need for new electrical generators.

It should also be noted that two other factors also threaten the reliability of the electrical supply in Ontario. Our distribution infrastructure is in grave need of upgrading in order to maintain a stable supply of electricity to the residential and industry users in Ontario. Another major factor is the ageing workforce in the electrical power industry. Highly skilled, highly trained and experienced workers are the key to maintaining and operating the electrical system in Ontario. Many of these workers are approaching retirement or are actively being attracted to work opportunities abroad.

## Load Demand

Demand for electricity in Ontario is going to continue to increase. This is due to the fact that our population increases annually plus every year new technology produces more and more gadgets and equipment for the marketplace which use electricity. With this, the challenge to meet demand becomes more difficult each year.

In order for Ontario to be the engine of the economy in Canada we must be prepared to meet an ever increasing and stable supply of electricity in Ontario.

**The Following are our Comments on Supply Mix.**

**Conservation**

This is a subject that receives much attention but unfortunately the gains to be made are quite limited unless the general public is willing to endorse significant changes to our current culture and standard of living. Even if the public attitude was to be drastically changed, we believe that there will be only some limited gains in this area.

Canadians are big energy users. There are some simple and obvious reasons for this such as cold winters and hot summers. We are also a big country and have very long distances to contend with. In order to maintain our lifestyle and standards we only have limited opportunities to conserve.

All this means we are large energy users and will continue to require an increasing demand for electricity.

We believe that conservation measures will have only a limited affect on energy demand.

**Renewable Energy Supplies**

Environmentalists claim to be the only ones that promote these forms of energy supplies. Workers in the electrical industry are citizens & environmentalists. We support these iniatives but clearly understand that these forms of production of electricity will contribute very little to the overall requirements none the less they should not be ignored.

**Wind Energy**

Due to much media coverage many people believe that we can produce all of our electrical needs by utilizing wind power.

Wind turbines can make a contribution to the electrical supply. It appears that in Ontario wind power will have a capacity factor of at best 30 – 35%. We will need a back up supply for the remaining 65% - 70% of the time that the wind is not blowing. These facts indicate that this type of power source is, in reality, very costly.

**Coal Power Plants**

There is a good supply of coal in North America and the world. As indicated above the current coal plants in Ontario are ageing and the government plans to phase them out. These plants currently supply over 17% of our power needs. They are very crucial in meeting peak demand. These plants are normally required for peak loads and provide a very important backup for base load when other forms of base load generation are not available. What is forgotten is that these plants save the day at peak times. The 17% figure is very misleading. It represents overall supply where as on some days the coal

plants provide much, much more than 17%. New clean coal technology is now available which makes new coal power plants very attractive.

## Hydro Electrical

Overall these plants supply over 24% of our electrical needs. Again, similar to coal this number changes. These plants will serve us well for years to come provided that they are properly maintained.

There are a very limited number of realistic sites in Ontario where from an economical and local power supply demand justify any new hydro electric stations be constructed.

## Nuclear Power

This form of generation provides over 50% of our electrical needs. These plants produce no green house gases. They are viewed by many people as green energy. Nuclear Power provides a very high number of highly skilled good paying jobs for the citizens of Ontario. These plants will continue to serve us well into the future. In the short term these plants will require some rehabilitation in order to extend their useful life.

Canada is fortunate to have it's own Nuclear Power Plant technology known as CANDU. Candu plants have very good operating performance in Canada and abroad. These plants produce low cost power at a high capacity factor making them ideal for base load supply.

The Canadian Energy Research Institute (CERI) study of Levelised Unit Electricity Costs Comparisons of Alternate Technologies for Base Load Generation in Ontario (LUEC) August 2004 supported the fact that Nuclear Power Plants are ideal for base load supply.

Ontario's nuclear plants can have their life extended to supply power for an additional number of years. This will allow the province to maintain a stable supply of electrical power until new nuclear power plants are constructed and placed in service. The current restart project undertaken by Bruce Power is an ongoing example where private enterprise has seen the benefit and need to invest in life extensions of their existing generating units.

Other jurisdictions, namely New Brunswick, have recently decided to extend the life of their Nuclear Power Plant. They believe that the benefits of Nuclear Power out weighed the alternatives and will greatly assist them in reducing green house gas emissions in the province.

To meet the growing demand for power and to maintain a stable supply of electrical power, Ontario urgently requires several new nuclear power stations.

## Gas Fired Plants

A few of these generators have come on line recently. These plants can be constructed in a short time frame. On the downside the fuel costs are very high with predictions of ever increasing supply costs. The price of this gas is based on a supply and demand basis. Natural gas reserves are limited and to utilize it for electrical energy production will result in Ontarians and industry that rely on natural gas for heating being faced with very large increases in costs.

Significant amounts of environmentally damaging gases are released during the mining and distribution of natural gas. It should also be noted that natural gas power plants produce green house gases.

The CERI – LEUC Study 2004 found that gas generation is very unattractive due to forecast increases in the price of natural gas.

## Gas Fired vs. Coal Fired & Nuclear

One of our member unions has the bargaining rights at the new gas fired plant, Brighton Beach, in Windsor Ontario. This facility has a capacity of 585 MW.

There are less than 30 workers at this plant. A clean coal technology power plant of this size (585 MW) would possibly employ 200 workers & the green house gas production would be at about the same level.

A nuclear generating unit of similar capacity (680 MW) would employ up to 600 workers & produce no green house gases.

It is very easy to see, in our view, which type of generator would be the best for the community & Ontario. Naturally nuclear will be first followed by coal. Again on a cost basis this view is supported by the CERI – LUEC study of 2004.

## Conclusions

It is our view that it is quite clear some major decisions are required in order to maintain a stable supply of electricity in Ontario.

Another major factor is jobs for Ontarians. The recommendations that we will be putting forward will provide good highly skilled and good paying jobs for workers.

## Recommendations

The CNWC makes the following recommendations.

1. A new build nuclear plant must be a priority. The OPA should start the process for the citing of a new build. **It is imperative that this process begin as soon as possible.** As an environmental assessment for a nuclear new build is estimated to take up to 5 years.

2. The current fleet of OPG's Nuclear Units must where feasible be refurbished to extend their life in order for us to have a stable supply of electricity until new power stations are constructed and placed in service.

3. A decision is required as soon as possible on the refurbishment of Bruce Units 1 and 2.

4. There has been some mention that Ontario should look at different forms of Nuclear Generation technology other than the CANDU. It is very important to keep in mind that the Canadian CANDU is a proven technology which is very robust and has earned respected across the world. CANDU new builds will result in many jobs in Ontario and Canada as well will provide major benefits to Canadian Industry and the Government of Ontario. It is also worth noting that CANDU Power Plants that have been built abroad have been completed on time and on budget.

5. AECL's ACR reactor should be built in Ontario. This new state of the art power plant technology will provide many benefits to the Province and it's citizens.

6. Existing coal generations must be maintained until new generation is available. These units are required for base load back up & more important for peaking.

7. A new build clean coal technology must be given very serious consideration.

8. Wind power may be able to help the supply situation but only to a small extent.

9. Conservation realistically may save a small amount of power but will not offset the need for new generation.

The CNWC is of the opinion that immediate actions are required in this regard or Ontario will lose it's place as the leader of the Canadian economy and result in the loss of both industry and many good paying jobs. A safe, reasonably priced and stable supply of electricity is needed for all of the citizens & industrial users in Ontario to secure our future and that of our children.

Respectfully Submitted By

David Shier
President CNWC

# Solar and Ontario's Future Electricity Supply
## A Submission to the Ontario Power Authority
## By the Canadian Solar Industries Association
August 25, 2005

# 1 Introduction

Solar energy encompasses a variety of energy technologies – generating electricity to run lights and motors, heat for water and space heating needs, and illumination for the daylighting of homes and buildings. When considered separately they are often overlooked as being too insignificant to be considered as energy policy options for the future. Yet when combined, the power of the sun is impressive. The amount of solar energy falling on 15 square kilometres of land in Ontario equals the entire energy capacity of all the nuclear power plants in Canada. Given the international growth rates of solar technologies in other nations – solar could supply 8 million megawatt-hours or clean heat and electricity to Ontario by 2025 – enough to fully power over 700,000 energy efficient homes.[1]

In Ontario two specific technologies have considerable potential in providing electricity (or displacing electricity from other sources) into Ontario's power grid in the future: This submission is broken into three sections – an introduction and standalone sections for PV and solar hot water.

CanSIA believes that given the right stimulation that solar PV will be economic competitive by 2015-2020 to other generation sources. Solar hot water is competitive now yet requires financing to be attractive to homeowners.

Solar electricity (or photovoltaics) can, by 2025 provide 12,900 GWh of electricity for Ontario homes and other buildings while solar hot water can reduce the demand for electricity to heat hot water by 1,400 GWh. For the ratepayers of Ontario this would mean:

- 400,000 homes powered by PV with a power rating of 1,200 MW – providing 1,3000 MWh of electricity
- 800,000 homes with solar water heaters – 80,000 of which are reducing demand on electrical water heaters

# 2 The Solar Resource in Ontario

The solar resource of a region is dependent on two variables: the amount of available solar radiation; and the amount of roof space that is available for the installation of solar collectors. Studies in Canada and internationally show that the solar capacity of roofs far exceeds the energy needs of society as a whole.

One of the myths that the solar industry faces in Ontario is that we have a poor solar resource. This is not the case. Ontario has a better solar resource than both German and Japan – the world's leaders in exploiting solar energy. Toronto, as an example, has a better solar resource than Miami during the summer months when the demand for electricity is often at its peak.

[1] Based on national numbers in CanSIA's Sunny Days Ahead – A Solar Plan for Canada; November 2004

# 3 Feed-in Tariffs: A Support Mechanism for Solar Electricity

"*Solar PV is more valuable because it competes on the retail side of the customer meter not wholesale like other technologies. Key to good policy changes include consumer friendly interconnection standards, net metering and voluntary solar tariffs, which properly value distributed generation."*[1]

This section is a summary of CanSIA's Position paper entitled *Valuing Grid Connected Solar Electricity – Priming the Market in Ontario* - which was present to the Ontario Ministry of Energy in May 2005. A copy is available at http://www.cansia.ca/reports.asp.

Canada lags other nations in both the deployment of on-grid solar electricity and in its public stimulation of this market. Ontario, with the seriousness of its projected shortfall of energy generation capacity, has a unique opportunity to put Canada "back in the game." Feed in tariffs as proposed here will stimulate the market for PV in a sustainable method – allowing the industry and support structures to grow so that by 2015 it has the capacity to handle growth rates that will make solar PV a major supplier of electricity in Ontario in the following decades – providing upwards of 13,000 MW of generation by 2025.

The solar electric industry in Ontario is small and is limited in capacity to provide immediate energy relief. Yet it has the potential to play a major role in the future. This proposal by CanSIA recommends the introduction by 2006 of a program of Standard Offers Contracts (also called feed-in tariffs) that will begin to realize this potential. A 10-year program of selling 10-year "contracts" to the public at $0.42 per solar kilowatt-hour will begin this process.

Benefits of the Standard Offers Contract program for PV includes:

- Increasing sales for on-grid residential systems in Ontario from 50-60 systems a year to 5,000 per year by 2015;
- Increasing the average size of installed system from 0.9 kW to 3 kW;
- Resulting in an installed capacity of 40 MW of on grid residential PV and stimulating additional installations of 14 MW per year by 2015 (versus a current installed capacity of 0.3 MW and annual sales of 0.05 MW).
- Will result in a reduction of installed prices for PV in Ontario by 20% - putting the price of PV on par with other nations;
- Will stimulate further price drops in PV system costs at an average rate of 3% a year – following international trends.

This is not an expensive program for Ontario – if structured as a "public benefit charge" it would cost the average ratepayer $0.70 per year - less than the price of a chocolate bar.

## *3.1 Introduction*

Solar electricity (photovoltaics or PV) is the fastest growing energy source in the world – with annual growth rates of 35% or more. In Germany the market grew by 87% and 360 MW were installed in 2004 alone.

Canada however has lagged behind our major trading partners – we have only 11 MW of installed capacity whilst Germany has 768 MW. In 2003, Canada had only 26% of the average installed PV capacity per capita of twenty IEA reporting nations and Canadian governments invested only $0.27 per capita - just 14% of the international average. Further, Canada continues to drop farther behind as our PV sales growth rate falls below most other nations.

The primary reason that Canada is behind is the lack of government programs to support the initial deployment of PV and to help reduce market entry barriers. Solar can be a major source of electricity generation in Canada - but it needs government support to develop its markets.

The Canadian Solar Industries Association (CanSIA) believes that by 2025 Canada could have 39,000 MW of PV installed on Canadian homes[2] – 13,000 MW in Ontario - but only if we begin to act now.

### 3.2 Background

The Ontario Ministry of Energy (MOE), through the Electricity Restructuring Act and the Ontario Power Authority, has committed to boosting new electrical supply and support for renewable electrical energy sources. The Ontario Sustainable Energy Association (OSEA) was contracted by the MOE to provide a report with recommendations on support mechanisms for renewable energy sources. This report by CanSIA is in response to the OSEA report – and to clarify the needs of the solar industry in Ontario. It is in Ontario's best interest for CanSIA to assist in laying the foundation with OSEA and the MOE for a support program for solar electricity (PV) that is meaningful and sustainable for our industry and Ontario's homeowners.

CanSIA, in its "Sunny Days Ahead" Solar Industry Strategy, released in November 2004, made energy based production incentives (also called feed-in tariffs or Standard Offer Contracts (SOC)) one of the key financing mechanisms necessary to help boost new supply and support for solar energy in Canada.

The Canadian solar industry feels that this incentive would send a significant message to both new investors in the solar industry and to potential purchasers of solar technologies, and would create an important boost to economic development and growth for the solar industry in Canada.

OSEA's submission to the MOE demonstrates the many benefits of Standing Offer Contracts. CanSIA endorses the concept of Standing Offer Contracts for the PV technology. This report deals with the level of support for Ontario's solar industry that CanSIA believes is necessary to sustainably boost the market uptake of solar energy technology.

### 3.3 Objectives of a Standard Offer Contract for PV

CanSIA feels that the prime objectives of an attractive SOC for PV should be as follows:

- To demonstrate government support for solar. Government support, at a meaningful level, increases the public confidence in the viability of the technology and will bring new private investment into the solar industry.
- To help bridge the inequality of government support for other energy sources (nuclear & fossil fuels) with its support for solar.
- To stimulate the market for "grid-connected" PV in a manner that allows the industry to grow sustainably.

### 3.4 PV in Ontario

Presently, the majority of the solar technology sold in Ontario is for remote, off-grid markets - used in remote cottages and for the supply of power for other remote applications such as telecommunication towers. Globally, more than 78% of all sales of PV are in grid-connected markets however in Canada it is less than 5%.

Grid connected solar electric systems can supply many long-term benefits for Ontario and are well documented internationally. PV systems lessen the peak electricity demand resulting in less strain on Ontario's electrical transmission infrastructure and reduce the need to create capital intensive, new electricity generation facilities.

CanSIA firmly believes that, like in other nations, the grid-connected market will drive the growth of the solar electric industry in Canada resulting in making it a major supplier of electricity in Canada by the middle of this century. CanSIA also feel that the off-grid solar electric and solar thermal markets are important and believes that these markets need support at similar levels that area provided by our major trading partners.

It has been demonstrated internationally that where consumers begin producing their own energy – and have the ability to "sell" their green energy at a premium - that they become more aware of their own energy consumption and will increase their efforts to reduce consumption. Such awareness helps Ontarians to reduce their energy consumption, aiding the province's energy conservation and efficiency efforts.

### *3.5 Ontario's Solar Electrical Capacity*

The David Suzuki Foundation carried out a study[3] on the potential of renewable energies in Ontario in 2004. This report found that currently over 47% of Ontario homes have the potential of installing a 3-kW solar PV array – the typical size of a residential solar system in other countries.

It is technically feasible now to install over 3,000 MW of PV on single, detached homes in Ontario – generating over 3,200 GWh annually. Given the right policy conditions the technical potential for PV on all buildings in Ontario is over 14,000 MW by 2025 – generating 13,000 GWh annually.

### *3.6 OSEA's Recommendations to MOE for Solar*

OSEA has proposed to the MOE various Standard Offer Contract rates based upon the research conducted by Bernard Chabot and the outcomes of his Profitability Index Method (PIM). The PIM is based on the assumption that an investment in a renewable energy project must be profitable (or at least be cost neutral) for the investor. By setting a positive value for the Profitability Index a tariff rate is determined. The tariff rate is the basis for Standard Offer Contracts. The advantages of the PIM are well known however the main disadvantages (shared by almost all valuing methods that deal strictly with economics) are as follows:

- It is based on conventional economics that do not put a monetary value on the environmental costs of an investment.
- The method assumes the investor has access to capital. This favours larger commercial or corporate investors over the general public (residential) market.
- The method does not put a value on investor pride of ownership. Presently, pride of ownership is the largest force driving the residential PV grid-connected market. The current consumer purchasing decision drivers are similar to what drives the luxury automobile market.

OSEA has proposed a 25-year program – the program would last 5-years during which 20-year Standard Offer Contracts would be signed. OSEA, using the Chabot's Profitability Index Method, has recommended a SOC price of about $0.85/kWh for a 20-year contract period for solar generation. Under this contract price, according to Chabot, an investment in solar would be revenue neutral in Ontario.

If a financing mechanism for on-site solar generation was introduced in Ontario that was revenue neutral without first "priming the market", the Ontario solar industry fears it might create an unsustainable demand for its product resulting in poorly performing systems and dissatisfied customers. Building capacities in the industry, the training of installers, inspectors and LDCs, and educating the public are important issues that the first phase of a SOC program must address.

A SOC price for solar is needed, which is greater than the present retail price of electricity (as presently available for PV in net-metering) yet provides for a measured and sustainable growth strategy reflective of the current and future capacity of the industry. Growing too quickly will compromise the ability of the present Ontario solar industry to maintain the high level of quality seen in the Ontario market today.

CanSIA does not support the introduction of a rate of $0.85/kWh as the initial rate. CanSIA would prefer that the Ontario solar energy industry grow at a sustainable rate and this high rate could overheat the demand for solar technologies in the early stage of deployment.

CanSIA believes that a properly designed program will help the Ontario solar market attract a healthy base in Ontario of supporting resources such as training facilities, research and development of new technologies, new manufacturing capacity, as well as qualified system designers and installers. These in turn will provide benefits to the Ontario economy by providing jobs and the generation of wealth.

It is important to note that there are different risks posed by Standing Offer Contracts based on who holds the contracts for energy delivery. In the wind and biomass industries where generating plants are larger or centrally located it is often the manufacturer or affiliate companies that hold the energy contracts and hence they are insulated from possible program changes as they have the security of the contracts (often long-term and at a guaranteed price). However for the solar industry – it is the industry's customers (homeowners) that have the security of the contract – the industry must rely on the support program to stimulate sales of solar products and provide the stimulation for industrial growth. For the solar industry, more so than in other renewable energy industries, a long term commitment to Standard Offer Contracts is critical – a program lasting a minimum of 5 years with 10 years being considered optimum.

It must also be noted here that the SOC rate does not represent the "cost" of PV electricity. The SOC rate is used to stimulate demand for an energy generation source which is not accounted for in the same way as conventional energy sources. Using the same accounting methods that are applied to central power generation stations (such as wind farms or coal power plants) then the cost of solar electricity is in the range of $0.30-$0.35 per kwh – and dropping each year. The "avoided cost" benefits of solar PV are significant – one study recently valued these benefits at $0.29/kwh – see appendix 13.5.

### *3.7 Sustainable Growth of PV in Ontario - the Early Adopters Market*

New markets are started with innovative, pioneer companies – Canada does not have a lack of these firms – and – most importantly – pioneer customers or early adopters, who are willing to pay a premium for a new attractive product or solution.

A critical number of these early adopters are needed before the market expands into the general population. Such pioneers can be the government, on a national, provincial or local level, educational institutions such as universities, colleges and schools, and importantly for PV - individual homeowners. An important role of government is to encourage these market leaders and to create a popular demand for important future energy sources such as solar.

Currently the market for on-grid PV in Ontario is only created by "early" early adopters – CanSIA estimates that approximately 50-100 residential systems (total of about 20 kWp) are installed annually in Ontario. This market is exceedingly small due, in part, to the lack of any positive messages of support from government.

CanSIA recommends that the first stage of the SOC PV program be targeted to early adopters. This market does not require a "profit" to invest – but they do need a positive message from the government. Early adopters typically account for between 1.5-2.5% of the market. CanSIA estimates that this program would attract 30% of the early adopters, or about 13,000 homeowners, as shown in the following table.

**The Early Adopter Market in Ontario**

| | Total | Early Adapters (at 2%) | Program Target | Total in Program |
|---|---|---|---|---|
| Single Family, Detached Homes in Ontario | 2,200,000 | 44,000 | 30% | 13,200 |

While the demand from early adopter homeowners could expand rapidly - the current market for residential grid-connected PV in Ontario is exceedingly small – with a lack of basic capacity such as qualified installers, distribution mechanisms, etc. Thus the limitation to the size of the program initially is the growth rate that the small industry could sustain. Based on experience in other nations and industries as shown in the appendices, CanSIA feels that a sustainable growth rate would be in the order of 50 - 75% annually.

CanSIA recommends that a reasonable deployment target be as listed in the following table.

**Deployment Targets for a PV SOC Program in Ontario**

| Year | 2004 | 2005 | Program "Purchase" Period |
|---|---|---|---|

| | | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Growth Rate | -- | 20% | 50% | 75% | 75% | 75% | 50% | 50% | 50% | 50% | 40% | 40% |
| No. of New Systems | 50 | 60 | 90 | 158 | 276 | 482 | 724 | 1,085 | 1,628 | 2,442 | 3,419 | 4,786 |
| Size of Systems (kWp) | 0.9 | 0.9 | 0.9 | 0.9 | 1 | 1.5 | 2 | 2.5 | 2.5 | 3 | 3 | 3 |
| New Installed Capacity (MWp) | 0.045 | 0.054 | 0.081 | 0.142 | 0.276 | 0.724 | 1.447 | 2.713 | 4.070 | 7.326 | 10.256 | 14.358 |
| Total New Installed Capacity (MWp) | -- | -- | 0.081 | 0.223 | 0.498 | 1.222 | 2.669 | 5.382 | 9.452 | 16.777 | 27.033 | 41.391 |

The proposed program would begin in 2006 and see the installation of 15,000 residential PV grid-connected systems in Ontario by 2015.

Currently CanSIA estimates that the average size of residential solar on-grid systems sold in Ontario is 900 watts – less than 30% of the international average. This is due to the market segment that is currently attracted to purchase solar systems – "early" early adopters are making a statement – they are not driven by economics or their energy needs. CanSIA believes that the size of systems sold under the proposed SOC program will increase dramatically and will duplicate international averages of 3 kW per system by the end of the selling period – providing a double benefit from the program.

### *3.8 International Context and Experience*

Over twenty nations, including Germany, have successfully launched solar incentives in their domestic markets as far back as the early 1990s. Germany has used the feed-in tariff approach since 1992 to deploy 768 MWp of PV by 2004, generating 0.5 TWh of energy per year, or 0.1% of Germany's energy requirements. In 2004 Germany installed 360 MW connected to the grid and is now experiencing annual growth rates of 50-80%. During the course of this program, Germans have seen the cost of PV technology fall by 50% and have seen more than 20,000 jobs created in the solar energy industry. Germany has a solar resources that is 20-30% less than Ontario's.

Germany is not alone in its efforts to increase the uptake of solar electricity nor are Standard Offer Contracts the sole method used to stimulate initial growth of the PV on-grid markets. Governments in other nations have also used direct purchase subsidies and tax incentives, often combined, to build the capacities of their PV markets and governments at all three levels (federal, provincial, municipal) have been involved. The table below outlines the prices offered for Standing Offer Contracts in other countries.[4] Note that the level of support for photovoltaics (solar electricity) is consistently greater than other renewable energy technologies.

**First Year Fixed-Price Renewable Tariffs ($CAD/kWh)**

| Country | Photovoltaics | Wind | Hydro | Biomass | Contract Length | First Introduced | PV Rate When First Introduced |
|---|---|---|---|---|---|---|---|
| Austria | $0.960 | $0.125 | | | 13 | 1994 | 0.06 |
| California | $0.667 | | | | 3 | 1983 | |
| France <12 MW | $0.245 | $0.135 | | | 15 | 2000 | |
| Germany | $0.923 | $0.140 | $0.123 | $0.185 | 20 | 1992 | 0.13 |
| Italy | $0.804 | | | | 29 | 1992 | |
| Spain <50 MW | $0.676 | $0.106 | $0.106 | $0.106 | >25 | 1998 | |
| Portugal | $0.458 | $0.161 | $0.132 | | 12 | 1998 | |

Experience in Europe shows that Standing Offer Contracts work to grow the market. The European examples also show that the value placed on the different technologies varies across the countries. Fixed price tariff rates in Europe were determined from a variety of influences, from practical to political. The Profitability Index Method is only one such method for determining tariff rates.

### *3.9 An Ontario Rate for PV Standard Offer Contracts*

CanSIA believes that a SOC rate that provides approximately 40% of the cost of the installed PV system would be sufficient to stimulate the initial sales of grid-connected PV systems into the early adopter homeowner market in Ontario. At this early stage of deployment this rate should be sufficient to lower entry barriers for early adopters. Table 13.2 in the appendices shows the SOC rates at different support levels and contract period lengths. In both of the below cases the support level is constant at 40%:

- $0.42 per kWh over a 10-year contract
- $0.25 per kWh over a 20-year contract

While the cost of the program is approximately the same for 10 or 20-year contracts, CanSIA believes that a shorter contract period – but a longer program period – would more adequately meet the needs of the solar industry in Ontario as the benefits for the industry (and sales growth) relate more to the program "selling period" than the length of the contract provided to homeowners. We believe that a 10-year program of Standing Offer Contracts with 10-year contract periods is the preferred program for PV in Ontario.

- OSEA proposal: 5-year "sell" program; contracts lasting 20 years; total program = 25 years
- CanSIA's proposal: 10-year "sell" program; contracts lasting 10 years: total program = 20 years

An important element in a SOC program for PV is that the rate should be reviewed on a regular basis to insure that it is stimulating the market adequately. As the early-adopters market matures and the "early purchasers" begin entering the market it may be necessary to base the rate more on Chabot's Profitability Index Method. However PV installed prices are expected to fall dramatically as the market expands in Canada. CanSIA estimates that if sales per capita were to match international averages then this would immediately stimulate a 20% price drop in Canada. Further PV prices internationally are trending downwards at 3% per year and Canada will follow this trend. Finally, electricity rates in Ontario – while volatile – can be expected to move steadily upwards in coming years.

### *3.10 The Cost of the PV Standard Offers Contract in Ontario*

It must be remembered that the SOC rate is not the same as the subsidy rate. As the electricity is "purchased" from the owner of the PV system – the utility now has the ability to resell this electricity to other ratepayers and, as this is a "green energy" source, the utility may be able to sell this electricity at a premium "green" price. As this energy will be sold back to the actual PV system owner or to immediate neighbours there are virtually no transmission and distribution costs associated to this electricity.

The cost presented in the below table is based on current electrical rates in Ontario and does not take into account the potential of time of day or "smart" metering in which electrical rates are higher during daylight hours – this could make a significant impact on lowering the cost of the program.

**Annual costs ($,000) over the first 10 years**

| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | Total over 20 Years |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost (discounting retail cost of electricity) | $49 | $100 | $199 | $457 | $967 | $1,915 | $3,320 | $5,827 | $9,293 | $14,086 | $149,443 |
| Total Value of SOC | $68 | $139 | $278 | $643 | $1,372 | $2,739 | $4,790 | 8,483 | $13,652 | $20,888 | $ 229,773 |

One possible mechanism to fund the program is through a public benefits charge that is spread over the entire ratepayer base. If this mechanism is adopted it represents an insignificant value – the typical homeowner would only see their energy bill increase by an average of six cents per month ($0.70 per year) because of this program.

**Program Cost Spread Over Ratepayer Base**

| | 2006 | 2015 | Average 2006 -2015 | Averaged over program term |
|---|---|---|---|---|

| | | | | 2006-2026 |
|---|---|---|---|---|
| Assumption of Total Electricity Consumption in Ontario [TWh/year] | 150 | 150 | 150 | 150 |
| Program Costs / Total Consumption [$/kwh] | $0.00000045 | $0.000139 | $0.000035 | $0.000077 |
| Additional cost for an average Ontario household using 25 kWh / day [$/year] | $0.004 | $1.27 | $0.32 | $0.70 |

### *3.11 Concluding Remarks*

Ontario has the solar resource and Ontario has the potential market for residential on-grid PV systems. What it lacks is a solar industry that has the current capacity to supply immediately a major contribution to Ontario's ever increasing energy demand.

Other nations have identified solar technologies as representing a tremendous energy source for future needs – and have invested in these technologies to prepare them for their role. Consequently other nations are beginning to reap the rewards of these government investments – in energy generation, in new jobs and in wealth creation.

Ontario – through the Standard Offer Contracts proposed here by CanSIA can begin investing in the future of its energy supply – an energy supply that is both environmentally benign and economically sustainable. This investment is minor – costing the average ratepayer less than the cost of a single chocolate bar annually over the length of the program. It will stimulate the growth of the solar industry so that it has the capacity to provide upwards of 13,000 MW of generation by 2025.

Capacity building must begin as soon as possible if Ontario is to participate in the benefits of solar technologies being experienced internationally. CanSIA is calling on the Ontario government to introduce the necessary mechanisms to introduce standard offer contracts for solar, and other renewables, by 2006.

### *3.12 Benefits of On-Grid PV*

Source: Submission to the California Public Utilities Commission by the Americans for Solar Power (ASPv) coalition, May 2005

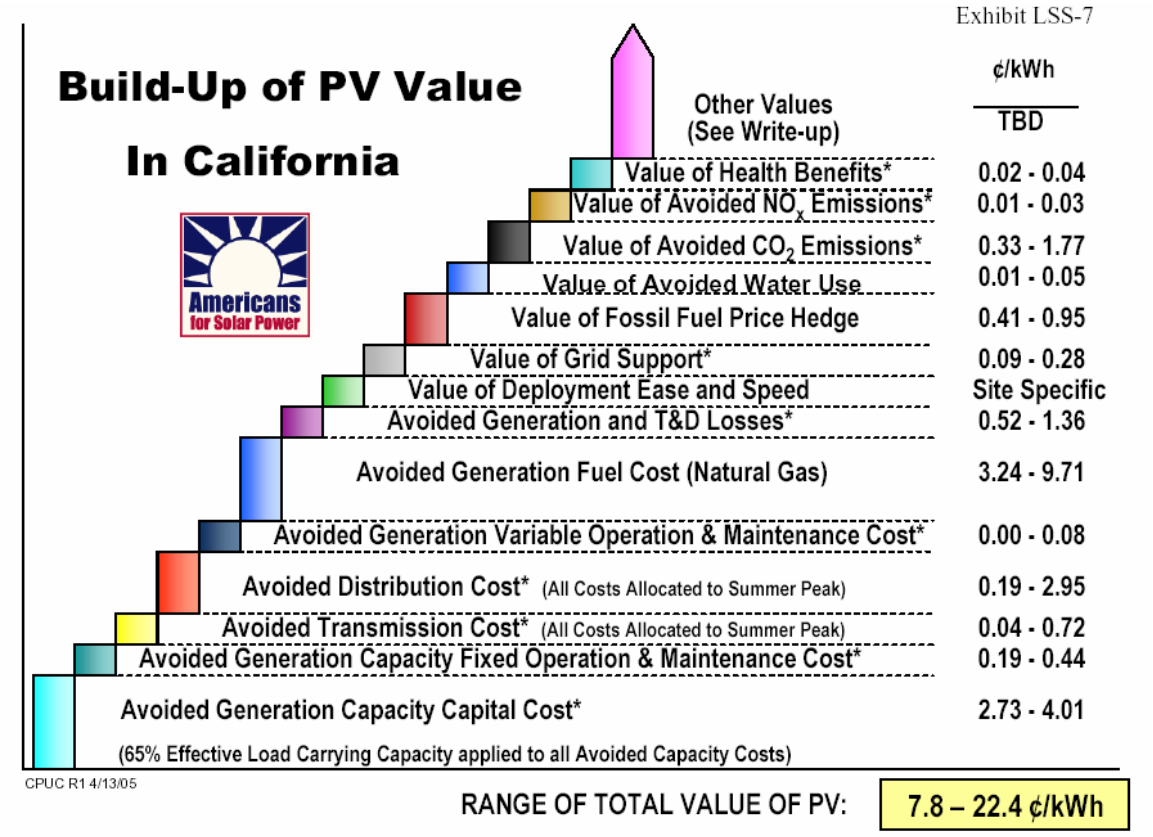
Exhibit LSS-7
Build-Up of PV Value
In California
Americans for Solar Power
¢/kWh
Other Values (See Write-up)
TBD
Value of Health Benefits*
0.02 - 0.04
Value of Avoided NOx Emissions*
0.01 - 0.03
Value of Avoided CO2 Emissions*
0.33 - 1.77
Value of Avoided Water Use
0.01 - 0.05
Value of Fossil Fuel Price Hedge
0.41 - 0.95
Value of Grid Support*
0.09 - 0.28
Value of Deployment Ease and Speed
Site Specific
Avoided Generation and T&D Losses*
0.52 - 1.36
Avoided Generation Fuel Cost (Natural Gas)
3.24 - 9.71
Avoided Generation Variable Operation & Maintenance Cost*
0.00 - 0.08
Avoided Distribution Cost* (All Costs Allocated to Summer Peak)
0.19 - 2.95
Avoided Transmission Cost* (All Costs Allocated to Summer Peak)
0.04 - 0.72
Avoided Generation Capacity Fixed Operation & Maintenance Cost*
0.19 - 0.44
Avoided Generation Capacity Capital Cost*
2.73 - 4.01
(65% Effective Load Carrying Capacity applied to all Avoided Capacity Costs)
CPUC R1 4/13/05
RANGE OF TOTAL VALUE OF PV:
7.8 – 22.4 ¢/kWh

# 4 Low Interest Financing: A Support Mechanism for Solar Hot Water

When talking about renewable energy forms, mainly electricity generation is addressed. However, this leaves out the enormous potential for renewable thermal energy. Especially in the residential sector water heating is responsible for a large share of the energy use. In the Canadian residential sector 21.6 % of the energy, 303.4 PJ, was used only to heat water in 2002. Water heating is the second largest energy consumer in the residential sector after space heating and requires much more energy than space cooling, lighting and appliances together. Solar Heating can be efficiently used for domestic hot water heating, reducing the need for fossil fuels and electricity as well as the monthly energy bill.

CanSIA projects that over 800,000 solar hot water systems could be installed in Ontario by 2025 – 10% (80,000) of which would be reducing the demand for electricity. The enormous potential of solar hot water heating becomes even more obvious when looking at other renewable energy forms. Taking wind turbines as an example approximately 250 MW would needed to be installed in order to produce the energy that solar hot water heating could save, only replacing electrical heaters in Ontario[2].

## *4.1 Solar Water Heating in Ontario*

Currently the market for solar domestic hot water (SDHW) systems in Canada is exceedingly small. Recent reports estimate the sales of solar water collectors (flat plate and evacuated tubes) in Canada are in the range of 250-1,000 $m^2$/year per year.[5] As a comparison in 2001 Austria installed 157,000 $m^2$ of solar DHW collectors, Denmark -26,000 $m^2$, Germany - 750,000 $m^2$, and the Netherlands -31,000 $m^2$. CanSIA estimates that there are 750 systems in operation in Ontario (as of 2001), which provides 0.092 PJ (2.502 eGWh) of thermal energy.

While there has not been an overall assessment of solar's potential in Ontario, there have been various studies in Canada and abroad that can be used as a starting point For example the community of Perth (population 3,000) in eastern Ontario has estimated that 74% of all the homes in the community could viably use solar domestic hot water systems.

## *4.2 Solar Hot Water Potential by 2025*

CanSIA estimates that 2,228,000 homes in Ontario could use solar for heating water. This could rise to 4,737,000 housing units by 2025 with proper house planning and solar access legislation in place.

However the use of electricity to heat hot water in Ontario is decreasing and CanSIA estimates that the market share of electrical heaters to heat domestic water will drop from 20.6% in 2001[6] to 9% by 2025

Thus solar hot water systems have the ability to displace 1,400 GWh of electricity and 50.7 PJ of natural gas annually by 2025.

CanSIA's projection of 800,000 systems in Ontario by 2025 is based that a financing program is in place with a pilot program initiated in 2006 (1000 systems in 2 years). This would be followed by annual sales growth of 50% a year (achieving 5,000 system installations annually by 2011) for 5 years and then growing at current typical international growth rates of 30% over the remaining period (2012-2025).

CanSIA does not foresee growth limitations in the industry infrastructure as being a barrier as currently there is a capacity in Canada to manufacture over 40,000 residential systems annually[7] and the Canadian market is very small compared to international markets so products are readily available for import into Canada.

[2] assuming a 30% capacity factor for wind turbines

### *4.3 Financing of Solar - Paying for Solar from its Savings*

Solar domestic hot water is one of the cheapest forms of energy available – when considered over the life of a solar hot water system the delivered energy cost for the consumer is in the range of 4 – 74 per kWh - versus the current delivered cost of electricity to the consumer in Ontario of 10-124 per kWh.

Paying up front essentially forces people to buy thirty or forty years of energy all at once, which is beyond the length of time most homeowners will own their home. With paybacks of typically 7-12 years the payback acceptance curve limits the size of the market to less that 10% of its potential. Financing is the primary obstacle to solar hot water's widespread acceptance.

Car dealers would sell few cars if customers were expected to pay the full sticker price in one payment. How then can it be expected that large number of consumers will buy a solar system without financing? If solar is to be marketed effectively it must be financed by an agency, which, for tax and investment reasons, is prepared to take a ten-year investment horizon thus effecting a lowering of monthly payments below the value of the monthly savings.

There is a critical requirement for third party financing which CanSIA has identified as far back as 1983.[8] Yet no action has ever been taken on this outstanding issue by the federal or provincial governments.

There are many international examples of solar financing programs. The German 100,000 PV roof program (1995-2000) is an example of this. The aim is to simplify investment by individuals and small and medium companies and to bring the monthly payments of the solar system down below the monthly energy savings. In this case the payback on solar systems is immediate and the consumer payback acceptance curve approaches 100%.

Low interest loans at less than market rates reduce loan payments and generation costs. This subsidy takes the form of an interest rate "buy down", which allows lenders to offer solar loans at a reduced interest rate and reduces the overall cost per system. The interest rate buy down has already been used successfully in a number of countries. New Zealand's government program provides subsidies for those customers who take out a load for the SDH system and the subsidy is equal to the interest rate for the first year.[9] In the US the states of California (SMUD), Idaho, Iowa, Nebraska, Oregon, Virginia, and Texas all have financing programs in place with low interest loans backed by the government or utilities.[10] India has over 100,000 such loans outstanding for solar water heating systems and this mechanism has now been introduced into the PV market and has already funded approximately 18,000 solar electric homes.[11]

The incentive applied as an interest rate subsidy is a small share of the total financing, with a lender having to provide most of the capital. Price distortion is minimal as the program subsidizes the financing cost and not the capital cost. The level of "total" subsidy provided through an interest rate subsidy is much less that with other approaches and overcomes the major barrier of payback acceptance.

This financing mechanism can be carried out through a number of different agencies or financing models including solar banks, solar mortgages, solar leasing or solar energy service companies (ESCOs). Appropriate delivery agents would include the energy utilities, conventional banks and trusts, and ESCOs.

However because there is a lack of an existing example of this mechanism in place in Canada it is unlikely that a private financing firm would undertake solar financing without an underwriting of the risks. For involvement of private financing it may be necessary for government to provide a "risk subsidy" in the range of 30-50% above standard interest rates.[12]

A solar financing agency run by a government agencies would allow this mechanism to enter the market place and increase confidence of solar in the financial markets. The solar financing would then be slowly evolved onto a number of potential private financing agencies including private utilities and banks.

CanSIA recommends that this program consists of a number of stages to build capacity sustainable and to slowly reduce government's involvement. It is important to note that there is no subsidy to cover the costs of the systems – these are still borne entirely by the end user – however the end user now pays for the system over a period of time and his payments are less than the energy savings.

### *4.4 A Financing Program for Solar Hot Water*

This program relates to a relatively short government involvement with the intent of turning over the accounts to a private financing program in about 2015 However the government could more proactively set up a program with a revolving fund that would insure that projects capital would not dry up once their involvement diminishes.

There are four phases to developing the market for solar water heating in Ontario:

1. Start-Up Phase

- To build capacity in the industry (training and reduce barriers)
- A quick ramp up with a target of financing 1,000 residential.
- A solar financing firm to be set up and run by the government with a short (4- year) lending program with loan terms of 10-years.

2. Government Demonstration of Financing Methodology Program

- The objective of this phase is to increase confidence in the market place (lenders, users), to prove that financing concept, and to fine tune the program.
- This would be a continuation of the start-up program with the intent of financing 5,000 residential.
- The value of the subsidy on interest rates would be under $2 million dollars with the average interest subsidy being under $600 per residential system.

3. Market Entry of Private Financing Firms

- The target is to have private financing firms begin to enter the market by 2010.
- The government would subsidize the program with an interest rate subsidy and a risk subsidy to the private lenders – a detailed study is necessary to project the cost of the risk subsidy however it may be insignificant if the government program shows the performance risks of solar SHW systems are insignificant.
- The subsidized interest rate program would slowly be phased out as the costs of convention energy rises and solar's payback is reduced to a consumer acceptable level.

4. Continuation of Financing Program

- By 2011 over 5,000 residential systems are being installed annually and the installed capacity in Ontario is 14,000 systems.
- At this level it is expected that it will be financially attractive for a financing agency to handle the solar loans without government support.

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[1] Submission to the California Public Utilities; Americans for Solar Power; May 2005; http://www.forsolar.org/?q=node/98

[2] Sunny Days Ahead – Insuring a Solar Future for Canada: A Solar Plan for Canada; CanSIA, November 2004' www.cansia.ca

[3] Smart Generation – Powering Ontario with Renewable Energy; David Suzuki Foundation, 2004

[4] OSEA Ministry of Energy report, 2005

[5] Solar Heating Worldwide: Markets and contributions to the energy supply; Werner Weiss and Gerhard Faninger, IEA Solar Heating & Cooling Program, Feb 2004

[6] National Energy Database 1990-2001; NRCan, 2003

[7] Conversations with Enerworks and Thermo-Dynamics, May 2004
[8] Third Party Financing of Solar Energy Systems – Phase 1 Report, CanSIA, 1983
[9] Solar Industries Association (of New Zealand) – website
[10] Review of Overseas Initiatives That Have Been Taken to Increase the Uptake of Solar Water Heating; NZ Energy Efficiency & Conservation Authority and NZ Solar Industries Association, 2002
[11] "PV Financing" article by Jyoti Painuly and Eric Usher; Renewable Energy World, January, 2004
[12] Third Party Financing of Solar Energy Systems – Phase 1 Report, CanSIA, 1983

Canadian Wind Energy Association
Association Canadienne de l'Énergie Éolienne

# CANADIAN WIND ENERGY ASSOCIATION

# SUBMISSION TO THE ONTARIO POWER AUTHORITY'S SUPPLY MIX CONSULTATION

## AUGUST 26, 2005

Prepared by Helimax Energy Inc., in collaboration with the Helios Centre, under the guidance and direction of the Canadian Wind Energy Association's Ontario Caucus

## EXECUTIVE SUMMARY

The Canadian Wind Energy Association (CanWEA) believes that wind energy can become a very significant part of Ontario's future supply mix. For the past few years, wind has been the fastest growing energy source in the world, registering an average annual growth rate of 32% over the last five years.

Faced with a requirement to replace 6,500 MW of coal-fired generation by 2009, Ontario has taken to renewable energy, and wind has emerged in the latest RFP as competitive and reliable; indeed, of the 395 MW retained under Renewables RFP I, 345 MW are for wind energy projects. It is further expected that wind will take the lion's share both of future renewables RFPs, and of the 10% Renewable Portfolio Standard (RPS) for 2010 set by the Ontario government. While wind figures prominently on Ontario's energy agenda for the next couple of years, thoughts must now be directed at wind's role in the future energy supply of the province, in the short, medium and long term.

The Ontario electric system is currently being pushed to its limit in its ability to respond to demand. Power demand has reached record levels this summer, reaching a peak of 26,160 MW on July 13 (IESO, 2005). Peak demand under normal weather is expected to increase to almost 27,000 MW by 2015, but extreme weather conditions would require an additional 3,000 MW of capacity. Taking into account the possibility of extreme weather, required resources for 2015 thus reach almost 30,000 MW under a medium-growth scenario, and 32,000 MW under a high-growth scenario.

An analysis of risks, environmental considerations and operational issues indicates that the following key factors must guide Ontario's future policy mix: cost certainty; reliability; environmental and social profile; social acceptance; safety; and synergies with existing system needs.

Many elements provided in this study demonstrate that wind can play a significant role in providing clean, reliable energy to Ontarians by replacing a portion of coal power in the short term and contributing significantly in the longer term. Indeed, we note the following highlights:

- Potential wind power capacity of approximately 33,500 MW within 25 km of transmission lines (winds 6.5 m/s and over); for winds over 7 m/s only, this potential is estimated at 6,150 MW[1];
- Potential of the electricity network to bring on over 5,000 MW of renewable energy with existing transmission and distribution capacity;
- Wind resource well distributed in areas of high-demand, namely in the southern part of the province;
- Competitively priced and negligible or no cost volatility in the long-run;
- Potential to contribute to peak load (particularly in winter);
- Relatively fast development and installation periods, contributing to coal replacement;
- Efficient coupling with local and imported hydroelectricity;
- Very low environmental and health impacts;
- High public acceptance level.

These elements lead us to believe that **Ontario should move towards a much greater penetration rate of wind in the supply mix, which should reach 20% of capacity or 6,000 MW by 2015, and significantly more by 2025**. In order to achieve these targets, certain market structures and policies will need to be developed and/or sustained by the government.

[1] This analysis has not made an assessment of the adequacy of these transmission lines to connect wind energy projects.

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# 1 INTRODUCTION

The Ministry of Energy of Ontario has recently requested advice from the Ontario Power Authority (OPA) on the future "supply mix" of electricity for the province. As recommended by the Ministry, the OPA will base its advice on internal and external sources. The Canadian Wind Energy Association (CanWEA), representing Canada's wind energy industry, has taken this opportunity to provide insight on the potential contribution of wind energy in the future supply mix of the province. More precisely, this brief prepared by Hélimax and the Helios Centre, addresses wind energy issues within the following item set forth by the Ministry:

- *Recommendations with respect to additions of new renewable energy capacity by 2015, 2020 and 2025, taking into account the targets already set by the Government of Ontario for 2007 and 2010;*

As well as the following "issue area" identified by the OPA:

- *Assessments of different supply technologies and resources in the Ontario setting, including (but not limited to) natural gas generation, coal gasification, nuclear (new and refurbished), wind, biomass and hydro-electric resources. The assessments will be of the greatest value where they (1) utilize recent source information or current data on capital and operating costs, performance characteristics, technology life cycle, environmental impacts and any other relevant characteristics and (2) present data on a consistent basis across the supply technologies and resources that would be suitable for planning studies.*

CanWEA believes that wind energy can become a very significant part of Ontario's future supply mix. In the last five years, there has been an average annual growth rate of 32%. Installed capacity now exceeds 50,000 MW worldwide. While Canada's installed wind energy capacity is still marginal at 590 MW (CanWEA, August 2005), many provinces have taken the wind path and are now planning for thousands of megawatts to be installed in the next 10 years. Based on actual policy orientations and market trends, Hélimax estimates that Canadian wind capacity will exceed 8,000 MW by 2013.

Faced with a need to replace 6,500 MW of coal-fired generation by 2009, Ontario has taken to renewable energy, and wind has emerged in the latest RFP as competitive and reliable; indeed, of the 395 MW retained under Renewables RFP I, 345 MW are for wind energy projects. It is further expected that wind will take the lion's share both of future renewables RFPs, and of the 10% RPS for 2010 set by the Ontario government.

While wind figures prominently on Ontario's energy agenda for the next couple of years, thoughts must now be directed at wind's role in the future energy supply of the province, in the short, medium and long term. This brief will provide insight on this issue. In the short term, Ontario faces an urgent need for generation under the coal replacement plan, and this brief will assess how wind energy can contribute to this phase-out. Moreover, this brief will assess longer-term trends and recommend achievable wind energy targets for 2015 and beyond.

The following section will present Ontario's current supply and demand, as well as trends in future supply mix, and key risks and key factors that should guide decisions on the future supply mix. Section 3 will provide an assessment of the role of wind energy in the future supply mix, namely by estimating total capacity, and discussing essential elements pertaining to wind, such as capacity value, compatibility with other energy sources and cost. The final section will provide recommendations for future wind energy targets, as well as important elements that will be required to achieve these targets.

# 2 ONTARIO ENERGY CONTEXT: DEMAND, SUPPLY AND ISSUES

In this section, we will provide a brief overview of Ontario's current supply-and-demand situation, its medium- and long-term outlook, as well as key issues affecting the future supply mix.

## 2.1 Supply and Demand

### 2.1.1 Short- and Medium-term

The Ontario electric system is currently being pushed to its limit in its ability to respond to demand. Power demand has reached record levels this summer, reaching a peak of 26,160 MW on July 13 (IESO, 2005). This value exceeds the forecast peak (with normal weather) by some 3,000 MW. So far this year, the Independent Electricity Market Operator (IESO) has issued twelve public appeals for businesses and residences to reduce their power consumption, and 5% voltage reductions have been imposed twice.

For the summer peak of 2005, the Ontario system had about 30,000 MW of installed capacity, including 650 MW of gas-fired generation added within the last year. However, given that almost 4,000 MW were unavailable (IESO, 2005b), it is clear that the reserve margin was practically non-existent.

Over 3,000 MW of new supply and demand-side resources have been committed or contracted with in-service dates through 2009. These include 2,434 MW of gas generation, and 356 MW of wind power.

Nevertheless, in the medium term, it appears that the situation will only grow more difficult. Energy demand is expected to grow annually by 0.9% and peak demand by 1.2%. Peak demand under normal weather is expected to increase to almost 27,000 MW by 2015, but extreme weather conditions would require an additional 3,000 MW of capacity. Taking into account the possibility of extreme weather, required resources for 2015 thus reach almost 30,000 MW under a medium-growth scenario, and 32,000 MW under a high-growth scenario.

**Table 2-1: Required Generation Capacity of Ontario**

| Year | Required Resources [MW] |
|---|---|
| 2005 | 26,000 |
| 2010 | 27,500 |
| 2015 | 30,000 |

### 2.1.2 The Coal Replacement Plan

The Ontario government is committed to phasing out the remaining 6,500 MW of coal-fired generation by 2009. The Lakeview Generating Station (1,148 MW) was closed last April, and the anticipated closure of the Atikokan, Thunder Bay and especially the Nanticoke station (almost 4,000 MW) will create a near term need for additional generation capacity.

In 2004, the 7,500 MW of installed coal-fired capacity provided 26.8 TWh of energy, or about 17% of Ontario's total energy demand. In addition, the essential grid services provided by the coal plants include load following (up to 80% of each unit's capacity range), operating reserve and reactive power. Resources will have to be found to replace all of these services.

The shortfall of existing and planned resources to meet these peak requirements reaches 5,000 to 6,000 MW in 2015, which exceeds Ontario's current interconnection capacity of 4,000 MW.

### 2.1.3 The Long Term

While the IESO's forecast extends only to 2015, the Electricity Conservation and Supply Task Force (2004) recommends that the planning horizon be extended to 25 years, given the long lead times associated with some supply options and the life expectancy of certain facilities. This is entirely consistent with the 20-year timeframe of the present Request for Written Submissions.

In the absence of IESO figures, supply and demand forecasts by the National Energy Board (2003) are provided for the 2015-2025 period. According to their latest assessments, Ontario's domestic peak demand through 2025 is estimated as follows:

**Table 2-2: Domestic Peak Demand for Ontario**

| Year | Domestic Peak Demand [MW] |
|---|---|
| 2020 | 31,482 |
| 2025 | 32,865 |

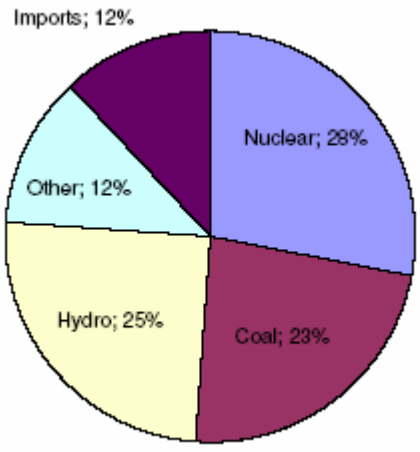
It should be noted, first, that these estimates reflect only domestic peak demand, and thus exclude the reserve margins included in the required resources forecast of the IESO. They also exclude any provision for extreme weather (3,000 MW in 2015, according to the IESO). Finally, these long-term forecasts date from 2003. For all these reasons, it is safe to assume that the required resources for 2020 and 2025 will substantially exceed the figures quoted in Table 2-2.

## 2.2 Supply Mix

### 2.2.1 The Current and Near-term Supply Mix

The current supply mix in Ontario can be characterized as follows:

Capacity




Energy

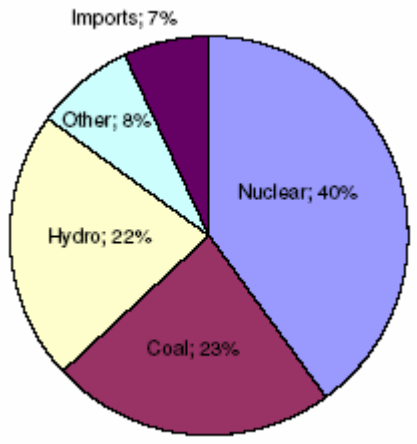



**Figure 2-1: Current Supply Mix in Ontario**

In the short term, an additional 2,434 MW of gas generation are committed, as well as 356 MW of wind capacity (IESO, 2005).

This demonstrates that significant new resources will be required to meet future demand. In the following sections, we will briefly address some of the key factors that should be taken into consideration in determining the future supply mix.

### 2.2.2 Key Risks – Financial

In this section, we provide an overview of key risks associated with the different supply options, which in turn will shape the discussion on key factors that should influence future supply mix. In addition to standard parameters such as cost, security of supply and air emissions, other key risks include health and environmental externalities and technology-specific factors. These include the following financial risks:

**Fossil generation**

- Substantial price risk and long term supply, with volatility and uncertainty driven by oil prices and by rising electric generation demand for gas in the rest of North America. While until very recently most forecasts called for gas prices to remain stable in real terms, the recent run-up in oil prices has driven gas to historic highs. These levels seem to constitute the "new normal", in the eyes of the U.S. Energy Information Administration (Energy Analects, 2005);
- GHG mitigation risk: the Canadian plan to meet its Kyoto commitments remains preliminary, and it remains unclear if it will be adequate to meet Canada's commitments under the Protocol. Increased efforts to meet these goals in the future could well translate into increased costs for GHG-producing generation. For instance, greenhouse gases emitted from Ontario's coal-fired power plants each year represent over 70% of the greenhouse gas emissions that Ontario would need to cut in order to achieve the 6% reduction envisioned by Kyoto[2], and it is clear that significantly larger reductions will be required in future years;
- Criteria air contaminants (CAC): reduction requirements under national/provincial programs could translate into increased costs.

**Nuclear power**

- Disposal of irradiated fuel: implementation of the draft strategy proposed by the Nuclear Waste Management Organization (NWMO, 2005) would cost $24 billion, without guaranteeing any final solution to this problem. Uncertainty about future clean-up costs weighs heavily on any future nuclear development.
- Disposal of high-, medium- and low-level radioactive wastes. The enormous costs foreseen by the NWMO apply only to irradiated fuel, and in no way address the disposal of other radioactive wastes, resulting both from operations and decommissioning of nuclear reactors.
- Other decommissioning costs; the accurate projection of which is highly uncertain, due to a number of factors[3]:
    - uncertainties in future regulatory requirements and responses (e.g., the extent to which *in-situ* disposal will be accepted; the nature and level of site abandonment criteria)
    - technical uncertainties related to decommissioning
    - the many enabling and supporting facilities, the nature and costs of which are not yet known, that will be required to carry out the decommissioning process
- Safety issues;
- Completion risk due to public opposition.
- Liability insurance costs

[2] Beyond Coal: Power, Public Health and the Environment. Ontario Public Health Association report. November 2002.
[3] AECL Comprehensive Preliminary Decommissioning Plan for AECL's Chalk River Laboratories. March 2005.

**Large scale hydropower**

- While the IESO assumes that 380 MW of new hydropower will be developed under the coal replacement plan, no specific projects are identified. While there is a significant potential of undeveloped hydro sites in Ontario, it is also clear hydropower alone cannot provide all required additional capacity in the timeframes required;
- Transmission risk due to potential public opposition to new transmission corridors.

### 2.2.3 Key Risks - Environmental

No generating technology is exempt of environmental considerations. However, it is extraordinarily difficult to establish a methodology to compare the diverse externalities of different generating technologies on a rigorous and quantitative basis.

Conventional generation technologies all involve significant greenhouse gas and/or ecosystem externalities. Thus, natural gas and coal produce significant emissions of greenhouse gases. Coal and uranium mining, storage hydropower and (to a lesser extent) natural gas extraction all involve significant ecosystem disruption.

More specifically, the key environmental and social concerns associated with different energy sources include:

- **Natural gas:** CO2 emissions from operations (greatest for single cycle; least for cogeneration); $CH_4$ emissions from extraction, processing and transport;

- **Coal:** High CO2 emissions; high criteria air contaminants (particularly sulphur dioxide and nitrogen oxides, both precursors for acid rain and smog, which can result in human health and environmental impacts); release of persistent toxins (e.g., mercury) into the atmosphere, which accumulate in the environment and in the food chain;[4] high land-use externalities related to extraction;

- **Nuclear:** Pollution and cancer risk related to mining and milling; damage to the environment and human health due to radioactive releases (e.g. tritium) during routine operation; risk of severe social and environmental damages following a nuclear accident; ecosystem damage resulting from water temperature modifications during operations; security and environmental risks related to spent fuel; the absence of appropriate disposal methods for radioactive waste, at every stage from mining through decommissioning;

- **Large scale hydropower:** loss of unique ecosystems, loss of scenic, recreational and ecotourism resources, loss of biodiversity; fragmentation of wilderness by new transmission corridors, interference with First Nations subsistence economies and access to resources;

- **Small scale hydropower:** ecosystem, recreational and social issues;

- **Wind power:** avian fauna, visual impacts, noise (all considered minor or null with proper project siting).

DSS Consultants (2005) estimated the total annualized cost of the current supply mix in Ontario to be $4.4 billion, where 77% of this cost is related to health and environmental damages. Annualized costs if the current coal generation were to be replaced with gas would be reduced to $2.6 billion, of which just 20% would be related to health and environmental damages. Following this logic, it seems reasonable to conclude that, if coal generation could be replaced entirely with wind power, these costs could fall considerably lower, by saving most if not all of the $0.5 billion in health and environmental costs attributed to gas.

Finally, the Ontario Medical Association (2005) estimates that economic cost of air pollution to the healthcare system and due to productivity loss is $880 million a year. It is also estimated that air pollution will be responsible for 5,829 premature deaths in Ontario in 2005, as well as 16,800 hospital admissions and 60,000 emergency room visits[5].

[4] Ontario's Changing Electrical Sector: Implications for Air Quality & Human Health. Toronto Public Health - Health Promotion & Environmental Protection. Kim Perrotta, MHSc, Environmental Epidemiologist & Fe de Leon, Environmental Researcher. March, 1999.
[5] "Loss of life" and "Pain and suffering" are estimated at more than $7 billion dollars a year.

### 2.2.4 Operational Issues

The urgent need to replace existing coal facilities in the Ontario grid creates very significant operational constraints for new power supply. These include:

- Baseload generation;
- Reactive power and voltage control capability in Greater Toronto, the Golden Horseshoe and the Kitchener-Waterloo-Guelph areas;
- Load following capability; and
- 10-minute and 30-minute operating reserves.

While all these services are currently provided by coal plants, it is not necessary that all replacement resources provide them all. Rather, system planners must ensure that they be provided collectively by the mix of new resources to be acquired.

Several studies suggest that, despite its non-dispatchability, wind power can make a real contribution to supplying aggregate needs. Raphals (2005) demonstrated, based on 2004 hourly wind and demand data, that 990 MW of wind generation would have been more valuable to Hydro Quebec-Distribution than an equivalent quantity of baseload power, due to consistently high wind generation during the periods of greatest demand. The study published by CanWEA (2005c), using historical data with a 10-minute timestep, demonstrated considerable correlation between wind and demand during the winter season. The fact that the wind potential is concentrated in southern Ontario (see section 3.2, below) may allow wind facilities there to contribute to reducing the reactive power needs created by the coal shutdown. Detailed analysis of the Ontario wind resource in the context of the Ontario power system is necessary to evaluate the degree to which wind power can contribute to meeting these needs.

### 2.2.5 Key Factors

Economic cost is an important factor in choosing new resources for the Ontario system, but it is not the only consideration.

According to the previous analysis on risk and environmental and operational considerations, CanWEA believes that the key factors that must guide Ontario's future policy mix are the following:

- Cost certainty;
- Reliability;
- Environmental and social profile;
- Social acceptance;
- Safety; and
- Synergies with existing system needs

# 3 WIND GENERATION IN ONTARIO: POTENTIAL, BENEFITS AND ISSUES

Unlike conventional power which, depending on the technology, can meet base load needs or follow loads, wind power is both variable and non-dispatchable. However, wind power has interesting characteristics that need to be analyzed in order to properly estimate the value of adding wind generation into the long-term supply mix and examine how it can contribute to replacing coal in the short term.

This section discusses the elements required to evaluate wind as a sustainable component of the supply mix in Ontario.

## 3.1 Wind Energy Potential

Quantifying the total potential for wind energy capacity in Ontario sets upper limits on the amount of wind power that could potentially be integrated into the supply mix with current technology. The approach used to quantify the total wind power potential was limited by the timeframe and budget available for the study. The methodology involves overlaying land constraints on the wind speed map published by the Ministry of Natural Resources at 1-kilometre resolution and at an elevation of 80 metres (see Appendix B). From the surface area available to be developed and an assumption that 3 MW can be installed per square kilometre, the total installed capacity available in the province was estimated. Details about the methodology and hypotheses used to calculate the potential are found in Appendix A. The results of the analysis are presented in Table 3-1.

**Table 3-1: Potential for Installed Wind Capacity**

| | Wind Class | |
|---|---|---|
| | **Good** | **Very Good** |
| Wind speed [m/s] | 6.5 to 7.0 m/s | Above 7.0 m/s |
| Average wind speed [m/s] | 6.75 | 7.25 |
| Net Capacity factor [%] | 31.1 | 33.4 |
| Potential prior to considering distance to transmission lines | | |
| [MW] | 355,344 | 38,979 |
| [TWh/year] | 968.1 | 114.0 |
| Potential within 50 km of transmission lines | | |
| [MW] | 41,388 | 7,164 |
| Portion of total potential capacity | 11.6% | 18.4% |
| [TWh/year] | 112.8 | 21.0 |
| Potential within 25 km of transmission lines | | |
| [MW] | 27,324 | 6,153 |
| Portion of total potential capacity | 7.7% | 15.8% |
| [TWh/year] | 74.4 | 18.0 |

*all wind speeds estimated at 80 m agl. It should be noted that higher wind speeds would be estimated for 100 m agl.

There are four items to be retained with respect to the wind energy potential:

- *For the whole of Ontario*, the potential installed capacity in areas with winds greater than 7.0 m/s is estimated at 39,000 MW. An additional potential of 355,400 MW under 6.5 to 7.0 m/s winds is also identified.

- *Within 50 kilometres of transmission lines,* the potential is evaluated at 7,200 MW where the wind resource is above 7.0 m/s; we note that in this wind class winds are mostly located in the 7.0 to 7.5 m/s bracket. An additional potential of 41,400 MW under winds ranging from 6.5 to 7.0 m/s was also identified, for a total of 48,600 MW of potential capacity within 50 kilometres of transmission lines.

- *Within 25 kilometres of transmission lines*, the potential is evaluated at 6,200 MW where the wind resource is above 7.0 m/s. An additional potential of 27,300 MW under winds ranging from 6.5 to 7.0 m/s was also identified, for a total of 33,500 MW of potential capacity within 25 kilometres of transmission lines.

- Average wind speeds in Ontario are comparable to those of Germany, which has a total installed wind generating capacity over 17,000 MW, using less efficient, earlier generation turbines.

This analysis of wind energy potential has not made an assessment of the adequacy of transmission lines to connect wind energy projects. However, in the context of RFP II, the Ministry of Energy, in consultation with the IESO and Hydro, analysed the operating characteristics and physical constraints of the electrical network to evaluate the potential to install renewable energy that can be "reliably integrated". The result of the analysis was to place limits of the installed capacity on certain transmission and distribution lines in the province. Based on our understanding of the document, the combined potential of these constrained lines is 5,265 MW. Additionnaly, other lines not explicitly mentioned in the report can offer additional capacity and the Ministry has stated that there are three unrestricted 500 kV lines and one unrestricted 230 kV line. This would imply that not only does Ontario have a large amount of wind resource near transmission lines – it also means a significant amount of this wind resource can be tapped without significant upgrades to the transmission system.

## 3.2 Geographic Location of Resource

As wind speeds are influenced by a number of factors, including local climate, time of year, time of day, obstacles in the wind trajectory, surface roughness, and orography, the wind resource in Ontario varies across the province.

A map showing the location of the wind resource in the province is provided in Appendix B. Areas with wind speeds above 6.5 m/s include:

- North-western and north-eastern shores of Lake Superior;

- Georgian Bay;

- Bruce Peninsula;

- Niagara Escarpment;

- North shore of Lake Erie;

- Sarnia-Chatham-Windsor;

- Prince-Edward County;

- Algonquin-Madawaska region;

- Northern Ontario (north of 50$^{th}$ parallel).

There are three main items to note about the geographic location of the wind resource:

- A good wind potential is situated in southern Ontario; these locations are in proximity to the large load centres and areas where the IESO has identified a shortfall of generation capacity[6].

- The geographic dispersion of the wind resource reduces the need for interconnection or transmission line upgrades, as wind projects will tend to not be concentrated in one region alone (reduced "bottleneck" effect).

[6] The most recent IESO report about generation outlook report states that an additional 1,000 MW of generation capacity is required in the Western Greater Toronto Area (IESO, 2005).

However, tapping into the northern resources would require significant investments in additional transmission lines.

- The energy yield from wind farms distributed across geographic regions have often shown a certain complementarity which results in the fact that extremes, both high and low, of combined energy production are reduced due to meteorological patterns (Hélimax, 2005). a study published by CanWEA (2005c) has calculated that the aggregate energy yield of 17 proposed wind farms would be 60 to 70% less variable than the energy yield of a single wind farm.

## 3.3 Wind as Distributed Generation

While there are significant voltage regulation and system stability issues associated with the concept, when solved, there is an enormous potential for wind energy as a source of distributed generation (DG). DG has not gained much public awareness yet but could be a key driver for smaller clusters near existing loads.

Ontario has a wide network of distribution lines to which smaller projects could be connected. There is an intrinsic value that could be acquired by encouraging small, decentralized and geographically diverse projects to connect to the distribution grid. According to the Ontario Sustainable Energy Association (OSEA, 2005), benefits of connecting wind or other green energy sources to the existing distribution grid include:

- Improved system efficiency through reduced line losses;
- Load displacement that can also be coupled with demand side regulation;
- Avoidance of transmission system constraints for faster deployment;
- Optimization to reduce immediate transmission system upgrades;
- Regionally dispersed economic, social and environmental benefits
- Increased sources of capital from local community sources;
- Increased tax revenue from increased economic activity in rural areas;
- Flexibility in reaching (or exceeding) renewable goals.

Because of these significant benefits of distributed generation, such power is worth more than the power from large centralized power plants and should be compensated accordingly. As the tendering process places significant overhead on smaller projects, an alternative to encourage the development of these projects should be implemented. Standard Offer Contracts, as recommended by the Ontario Sustainable Energy Association and CanWEA, provide an example of the type of contract that could be offered.

Many European countries have embraced acquiring renewable generation through Standard Offer Contracts (SOCs). In doing so, these countries have encouraged significant amounts of installed capacity, including small scale for DG[7]. If Ontario were to proceed in a similar manner, the province could quickly acquire substantial additional wind generating capacity.

[7] As mentioned by OSEA (2005), SOCs enable farmers, cooperatives and First Nations to participate on an equal footing with large commercial developers.

## 3.4 Capacity Value, Integration Costs and Penetration Rates

Because wind power is not dispatchable, it cannot simply replace baseload or load following generating resources. System operators have been concerned that the variations in wind could increase the operating costs as it would be more difficult to follow the load or because there would be an increased amount of operating reserves required (Canadian Electricity Association, 2004). Recent advances in wind forecasting have improved the predictability of supply forecasting from wind farms.

Wind power does, however, contribute very significantly to serving loads, despite its intrinsically variable nature. The complex issues surrounding the integration of wind power into a regional grid can be broken down into questions of capacity value, integration costs and penetration rates.

### 3.4.1 Capacity Value

Though an intermittent source of power, wind is increasingly considered to contribute to peak load on a variety of energy grids around the world. As for any other source of energy, wind energy comes with a degree of supply uncertainty, but this is also the case for conventional energy plants (e.g. uncertainty linked to breakdowns).

Strictly speaking, the capacity value of a wind power project is measured by its effective load-carrying capacity (ELCC). However, given the inherent difficulties of determining this value, alternative methods have been devised. Grid operators across North America have not agreed upon a single method of assessing the capacity value of wind power:

> *"ISO New England relies on historic capacity factor, but may change to performance during the top 100 critical hours. PJM sets an initial capacity value for wind at 20% of nameplate capacity, which is then adjusted based on actual operating experience, resulting in a rolling three-year average capacity value. ERCOT assumes 10% of installed capacity, and Southwest Power Pool looks at the wind plant's performance during the top 10% of the hours of highest system load. These simplified methods may overstate or understate a wind generator's true capacity value, however, so it is best to rely on the ELCC method* (Holt, 2005:5)."

The capacity value depends mostly on the ability of a generating plant to deliver power during times of peak load. In a study published by CanWEA (2005c) used actual wind speed data to evaluate the capacity value of a fictional 2,000-MW addition of wind energy spread over 17 projects. Using two different methodologies[8], it found the capacity value of wind in winter to be 46-47% of its nameplate capacity, due in large part to the correlation between periods of high winds and low temperatures. In summer, however, the figure is only 18-19%. Given the bi-modal configuration of Ontario demand, both of these figures are significant. Even if access to additional summer peaking resources is needed, wind power's very significant contribution to meeting the winter peak must be recognized.

### 3.4.2 Integration Costs

Because of its intermittency, wind power raises technical issues related to power system operations, including load following, operating reserves, reactive power requirements, voltage control, frequency regulation, etc. The vast majority of these concerns can be met by other resources, though at a cost. The question thus becomes one of estimating the cost of ancillary services made necessary by the addition of wind power into the supply mix.

A recent study led by the Utility Wind Interest Group (UWIG, 2004) reviews nine separate case studies carried out in the U.S. to evaluate costs related to unit commitment scheduling, load following reserves and energy, and regulation reserves. While these costs tend to increase with wind penetration in the system, they remain very

[8] The first method calculates mean wind output during the top 5% of 10-minute loads during the season; the second method calculates mean output during the 10 highest-load days.

reasonable. Thus, in PacifiCorp's study of the consequences of increasing wind penetration to 20%, integration costs were only US$5.50 per MWh. For lower penetration rates, integration costs were in the $3-4 range.

The report published by CanWEA (2005c) of 17 proposed wind projects in Ontario, totalling 2,000 MW or approximately 6.7% of peak load, shows a need for increased operating reserves of only 200 MW, or 10% of installed wind capacity. While not insignificant, this is a far cry from the position, quite common until recently, that wind power required 1:1 backup from conventional sources.

### 3.4.3 Penetration Rates

The integration issues described in the previous section increase in importance as the penetration rate of wind in a system increases.

It is also clear that the issues raised by a given penetration rate differ depending on how interconnected the control area is with neighbouring areas. Thus, a rate that would be unsustainable in an insular system that must be totally self-sufficient at all times (e.g. the Big Island of Hawai'i) might present no difficulties at all in a highly interconnected grid (e.g. Denmark).

Assessing the optimal penetration rate is thus a complex exercise that must take into account the precise characteristics of the grid in question. Such a study is of course beyond the scope of this brief. However, experiences of other large grids can give us some idea of what one might expect.

Several studies have looked at penetration rates in capacity terms. In Québec, Hydro-Québec TransÉnergie considers a wind penetration rate of 10% to be achievable without major problems; RSW (2005) considers however this rate to be "prudent and conservative", adding that simulations could indicate higher penetration levels. Similarly, in preparation for New York State's new RPS, GE Energy (2005) found in a study for NYSERDA that a wind penetration rate of 10% (based on the 2008 peak load) would not create significant reliability problems.

However, evidence from the United States demonstrates that wind energy penetration rates can be higher, without affecting reliability and without resulting in excessive integration costs. Examples reported by Smith et al. (2004) include:

- Pacificorp: at a wind penetration rate of 20% (equivalent to 2,000 MW), average integration costs were found to be just 0.55¢US/kWh (0.25¢ for incremental reserve and 0.3¢ for imbalance cost).
- We Energies: at a wind penetration rate of 29% (equivalent to 2,000 MW), integration costs were estimated at 0.3¢US/kWh.
- Great River Energy: at a wind penetration rate of 16.6%, integration costs were estimated at 0.45¢US/kWh.

Finally, countries with some of the highest wind energy growth rates have already achieved high penetration rates, not only in terms of capacity but also in terms of electricity production. For example wind energy accounts for 18 % of total electricity production in Denmark, for 6% in Spain and for 5 % in Germany (BTM Consult, 2003).

It is important to note that rapid growth of penetration levels have been observed in Europe. For example:

- Germany's installed wind capacity increased from 6,000 MW in 2000 to over 16,000 MW in 2004, i.e. a 10,000 MW leap in only four years;
- From just over 200 MW in 1997, the Spanish market has been steadily growing at annual rates of more than 30%. Last year Spain reached a record level of 2,065 MW installed, a 33% increase on 2003, taking the total to 8,263 MW, and leading the world in annual installations for the first time, just pushing ahead of the previous leader Germany. As a result of its continued success, the previous Government target of 13,000 MW installed wind capacity in 2010 has been updated to 20,000 MW in 2011. In 1999, the target was 8,900 MW by 2010, considered ambitious at that time. The Government's new target would see wind energy supplying 15% of national electricity consumption, up from 6.5% today.

**These assessments, combined with projected advancements in wind energy technology, lead us to believe that Ontario should consider a steady increase in wind penetration rates, to reach 20% of capacity by 2015**.

## 3.5 Wind-hydro Coupling

Because of its extraordinarily high degree of operational flexibility, hydropower is a natural complement to wind power. Indeed, hydropower output can be modified practically instantaneously (within certain limits), thus it is ideally suited to smoothing the "rough edges" of intermittent wind generation. This synergy is recognized by the IESO, which is open to the idea of partnering wind and hydro facilities as a means to optimize the use of both of these generating sources.

As discussed above, one of the key shortcomings of wind power is its inability to be dispatched. This can potentially raise problems in the regulation horizon (1 minute to 1 hour), the load-following horizon (1 hour to 1 day) and the unit commitment horizon (1 day to 1 week) (UWIG, 2004). At the same time, it is well known that hydropower excels in precisely this area, especially with respect to short time frames.

The Bonneville Power Authority has made great strides in making its hydropower system available for wind integration. For wind generators located within its control area, it offers a Network Wind Integration service, which effectively nets wind against demand to reduce the variability of both. For wind generators located outside its control area, it offers a Storage and Shaping service, in which it accepts the fluctuating wind generation and returns an equivalent quantity baseload power (at a price). Hydro-Quebec Production is offering a similar service to support the 3,000 MW of wind power to be developed over the next decade.

Hydropower already represents 25% of Ontario's installed capacity, and contributes greatly to matching supply with loads. The question that must be addressed, which is beyond the scope of this brief, is to what extent the existing hydro system has additional regulation and load-following capacity that can be used to facilitate wind penetration.

If the load-following hydro capacity of the hydro system in Ontario continues to have some flexibility, the potential wind-hydro synergies could be quite important. In the event that the load-following hydro capacity of the hydro system is already being used to its limits, however, increasing this capacity is not a simple task. There are significant obstacles to developing new large storage hydro projects in Ontario. Many small hydro installations are run-of-the-river (without storage). Even those that do have some storage may be limited in their capability to respond within the timeframes required by the system operator, due to their location or other operational constraints.

Hydropower imports may be of some help in this regard, especially from Manitoba, which is synchronized with the Ontario grid – though other technical obstacles related to transmission distance may also come into play. On the Quebec side, however, the AC-DC-AC interconnections would limit their usefulness for regulation and load-following.

It should be noted that pumped storage, while not an energy resource, could help to facilitate wind integration. Pumped storage projects are presently excluded from the renewables RFP but, if additional buffering capability is needed above and beyond the existing hydro system, it might be appropriate to look into the possibility of developing such projects.

## 3.6 Cost

Based on a set of assumptions and a typical wind farm of 100 MW in capacity[9], it is estimated that wind power would cost approximately 8.0 to 8.5 cents/kWh in Ontario, for net CFs of 33.42% and 31.12% respectively[10].

[9] Assumptions are based on current knowledge of wind energy projects and financial parameters, such as tax treatment, interest rate, indexation rates, debt/equity ratio, capital and O&M costs, etc. Assumes no production or green energy credits. Costs may vary depending on choice of financial parameters, project location, interconnection fees, turbine cost, etc.

Assuming technological gains resulting in decreases in total project costs (around 2% a year) it is estimated that wind would cost approximately 0.7 cents less in 2010 (Table 3-2). While costs are expected to decrease further in the longer term, no quantitative assessment is available at the present time.

**Table 3-2: Cost Estimates for a Generic 100-MW Wind Energy Project**

| | Wind Class | |
|---|---|---|
| | **Good** | **Very Good** |
| Wind speed [m/s] | 6.5 to 7.0 m/s | Above 7.0 m/s |
| Average wind speed [m/s] | 6.75 | 7.25 |
| Net Capacity Factor [%] | 31.12 | 33.42 |
| Cost [$2005] | | |
| 2005 [¢/kWh] | 8.5 | 8.0 |
| 2010 [¢/kWh] | 7.7 | 7.3 |

In preparing these cost estimates, capital cost was set at $1.7 million per MW installed which is likely an underestimate in the current market where increases in steel prices and a turbine supply shortage have resulted in a significant short-term increase in prices over the past year.

Nevertheless, today's costs remain competitive with gas-fired electricity (cost estimated at $60-90 / MWh over the next five years by the Delphi Group (2004)), and are almost certainly advantageous in the long term, where wind costs are projected to decline and gas costs will very likely rise.

In Biewald (2005), the cost of generating energy from nuclear, wind, and gas were compared. While the cost of producing electricity with nuclear energy was estimated at 6.8¢US/kWh (US$2003) and natural gas costs were estimated at 4.7¢, wind energy cost estimates ranged between 4.5 and 6¢.

This is to say that wind, in certain conditions and with respect to the electricity market in Ontario, is competitive and is expected to be more so in the future, especially when environmental externalities and uncertain fuel costs are put into play.

As indicated by Awerbuch and Berger (2005 : 49): "More specifically, the results suggest that increasing the share of wind and similar fixed cost renewables in the generating mix up to levels of 12% and more does not increase overall portfolio generating costs as compared to the currently projected year-2010 EU mix. Under many circumstances, additional portfolio shares of renewables even serve to reduce overall cost and risk. This result, which holds under a wide variety of assumed conditions, runs contrary to most analyses and to the widely held conception that given their higher stand-alone costs, adding renewables to the conventional mix can only serve to increase overall generating cost."

[10] These CFs correspond to average wind speeds of 6.75 and 7.25 m/s. The Ontario Ministry of Natural Resources has estimated that utility-scale wind projects can be competitive in areas with wind speeds above 6.5 m/s.

## 3.7 Benefits of Wind Power

There are additional benefits of including wind power in the Ontario supply mix which have not been addressed in depth in this document, but are worth noting. These include:

- Reduction of air pollution and compliance with international, national and provincial commitments;
- Considered a very low-impact energy source with high public acceptance; An Ipsos-Reid poll commissioned by CanWEA[11] highlighted the following:

  96% support (67% strongly support) the continued development of wind energy.

  92% believe wind energy will play a significant role (43% very significant) in meeting Canada's future energy needs.

  51% feel that wind energy is currently an important factor in addressing Canada's energy needs and will continue to be in 10 years.

  92% support the development of a wind project for their community (54% strongly support).

  71% are interested in investing in a wind project for their community (22% very interested).

  74% are interested in the possibility of a home wind turbine (32% very interested).

- Diversification of the supply mix;
- Energy security by eliminating dependence on imported fossil fuels;
- Modular and rapid to install

  For example, once a project is permitted and wind assessments are completed, new capacity can be deployed in 12 months[12].

- Creation of employment, regional growth and innovation;
- Provision of a hedge against the volatility of fossil fuel prices;
- Fuel source is free, abundant and inexhaustible;
- Technology with 95-98% reliability rate.

[11] For more details, see http://www.canwea.ca/downloads/en/PDFS/Membership_Fact_Sheet_-_Public_Opinion_ResearchJune_29.pdf

[12] The benefit of modularity is that it allows for a faster response to changes in demand. Wind is a technology that can respond to changes in demand quickly and can save the system from buying capacity in advance, should demand not materialize for example. On the other hand if demand increases unexpectedly, additional capacity can be added quickly to accommodate the increase.

# 4 CONCLUSIONS AND RECOMMENDATIONS

This brief aimed to assess the contribution of wind energy in Ontario's future supply mix. Many elements provided in this study demonstrate that wind can play a significant role in providing clean, reliable energy to Ontarians by replacing a portion of coal power in the short term and contributing significantly in the longer term. Indeed, we note the following highlights:

- Potential wind power capacity of approximately 33,500 MW within 25 km of transmission lines (winds 6.5 m/s and over); for winds over 7 m/s only, this potential is estimated at 6,150 MW (note that this analysis has not made an assessment of the adequacy of these transmission lines to connect wind energy projects);
- Potential of the electricity network to bring on over 5,000 MW of renewable energy with existing transmission capacity;
- Evidence from other systems of high wind penetration rates without unreasonable integration costs;
- Wind resource well distributed in areas of high-demand, namely in the southern part of the province;
- Competitively priced and negligible or no cost volatility in the long-run;
- Potential to contribute to peak load (particularly in winter as Ontario outside of Toronto is still a winter peaking province);
- Fast development and installation periods, contributing to coal replacement;
- Efficient coupling with local and imported hydroelectricity;
- Very low environmental and health impacts; high public acceptance level.

These elements lead us to believe that wind energy additions can be ambitious in the short-, medium- and long-term energy agendas.

**In the short term**, wind energy's fast development timeframe could contribute to replacing coal-fired generation. Indeed, wind energy is expected to take the lion's share of the upcoming renewable RFPs II and III, as in the previous RFP I where wind took 345 MW of the selected 395 MW. The combined wind power capacity from these RFPs could add up to 1200 MW, or just under 25% of all coal power capacity to be phased out by 2009. Assuming cost competitiveness and other benefits such as wind energy potentials located close to high-demand areas, wind could represent the larger fraction of the 10% renewable installed capacity by 2010, or 2700 MW, representing over 40% of coal capacity. It should be noted that according to the review presented in this study, such an addition of wind power to the system, representing a penetration rate just under 10%, would not create any operating constraints**. Accordingly, we believe that Ontario should increase its renewable energy objectives in the period leading up to 2010.**

**In the medium term**, evidence from other jurisdictions suggests that rapid increases in wind penetration are achievable without unreasonable increases in operation reserves or integration costs. Furthermore, current penetration rates are based on current technologies and methods; it is realistic that future advancements and technology maturity will improve abilities to integrate wind in power systems. While only 356 MW of wind will be installed at the end of 2005 and during the course of 2006, **we believe that Ontario should consider a steady increase in wind penetration rates, to reach 20% of capacity by 2015, or 6,000 MW**.

**In the long term, it is estimated that penetration levels could reach minimum levels of 25% or 8,000 MW by 2020, and 30% or 10,000 MW by 2025**. These long term targets are considered conservative as other jurisdictions are working to meet and exceed these levels in a much shorter timeframe, and we expect that such targets will need to be revised upwards as new developments in technology arise, new analysis of penetration levels is undertaken, and more experience is gained in working with wind energy in the electricity grid.

In order to achieve these targets, it is important to note, however, that certain market structures and policies will need to be developed and/or sustained by the government, such as:

- Maintaining commitments to phase out coal fired generation in Ontario;
- Promoting renewable energy, particularly wind power, as a significant government commitment with respect to meeting environmental requirements;
- Ensuring financial, fiscal and energy market structures do not create barriers to wind energy developments;
- Commitment to address interconnection constraints / barriers;
- Ensuring future procurement processes do not create barriers to wind energy developments;
- Ensuring that all required provincial and municipal approvals are streamlined.

As well, further analysis and research will be required on the following:

- Ontario's wind energy potential, integration and interconnection issues;
- Ontario's wind resource in the context of the Ontario power system, to evaluate the degree to which wind power can contribute to meeting system needs;
- Extent to which the existing hydro system has additional regulation and load-following capacity that can be used to facilitate wind penetration.

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# APPENDIX A: METHOD OF CALCULATING THE POTENTIAL INSTALLED CAPACITY

The methodology involves defining constraints, taking into consideration the following different technical and environmental constraints and their associated buffer zones: water bodies, roads, railroads, built-up areas, provincial parks, national parks, important bird areas, and transmission lines. By overlaying these land constraints on the wind speed map published by the Ministry of Natural Resources at a 1-kilometre resolution and at an elevation of 80 metres (see Appendix B), Hélimax estimates the surface area available that could potentially be developed.

Based on an estimate that 3 MW of wind can be installed per square kilometre, Hélimax estimates the total installed capacity available in the province for each wind speed class. Using average net capacity factors (Hélimax, 2005b) for each wind speed class, the total amount of energy available for wind power generation is estimated.

The 3 MW per square kilometre estimate is based on expert knowledge and previous constraints evaluations. For example, a 10 MW / square kilometre ratio was used for a recent Québec wind power potential assessment, which integrated several highly limiting land constraints. In the context of the present study, only high-level constraints were analyzed and factors such as social impacts and distance from individual residences were not taken into consideration.

## Constraint Zones

A GIS (Geographical Information System) analysis was performed to determine the constraints imposed on the land areas by cross-referencing GIS layers of information as per pre-established criteria based on Hélimax's professional experience.

Exclusion zones (the excluded distance varies by the nature of the constraint) were added for each of the constraints in the table below.

| Constraints | Suggested Buffer Distance |
|---|---|
| Hydrography (waterbodies and watercourses) | 500 m |
| Road | 500 m |
| Railroad | 500 m |
| Built-up area | 2 km |
| Provincial Park | Not applicable |
| National Park | Not applicable |
| Important Bird Area | 1 km |
| **Inclusion Zones** | **Required Proximity for Purposes of Study** |
| Transmission line | 25 km and 50 km |

The land use information was taken from publicly available databases at a resolution of 1:1,000,000. Maps at a higher resolution could result in different outcome for the potential. The location of the transmission lines was taken from Platts POWERMap Transmission Line data bank 2003. Subzone limits placed by the Ministry of Energy on the transmission lines have not been incorporated into the analysis. Hélimax makes no guarantee with respect to the accuracy of the maps used for quantifying the land constraints.

## Mesoscale Map

The Ministry of Natural Resources published a mesoscale map for the entire province of Ontario at a 1-kilometre resolution, prepared by Hélimax. Details of the wind speed map can be found on its website at www.ontariowindatlas.ca . At a resolution of 1 kilometre, the mesoscale map used for this analysis is suitable for preliminary estimates.

At the time of this study, only the 1-kilometre wind speed map of the province was available.

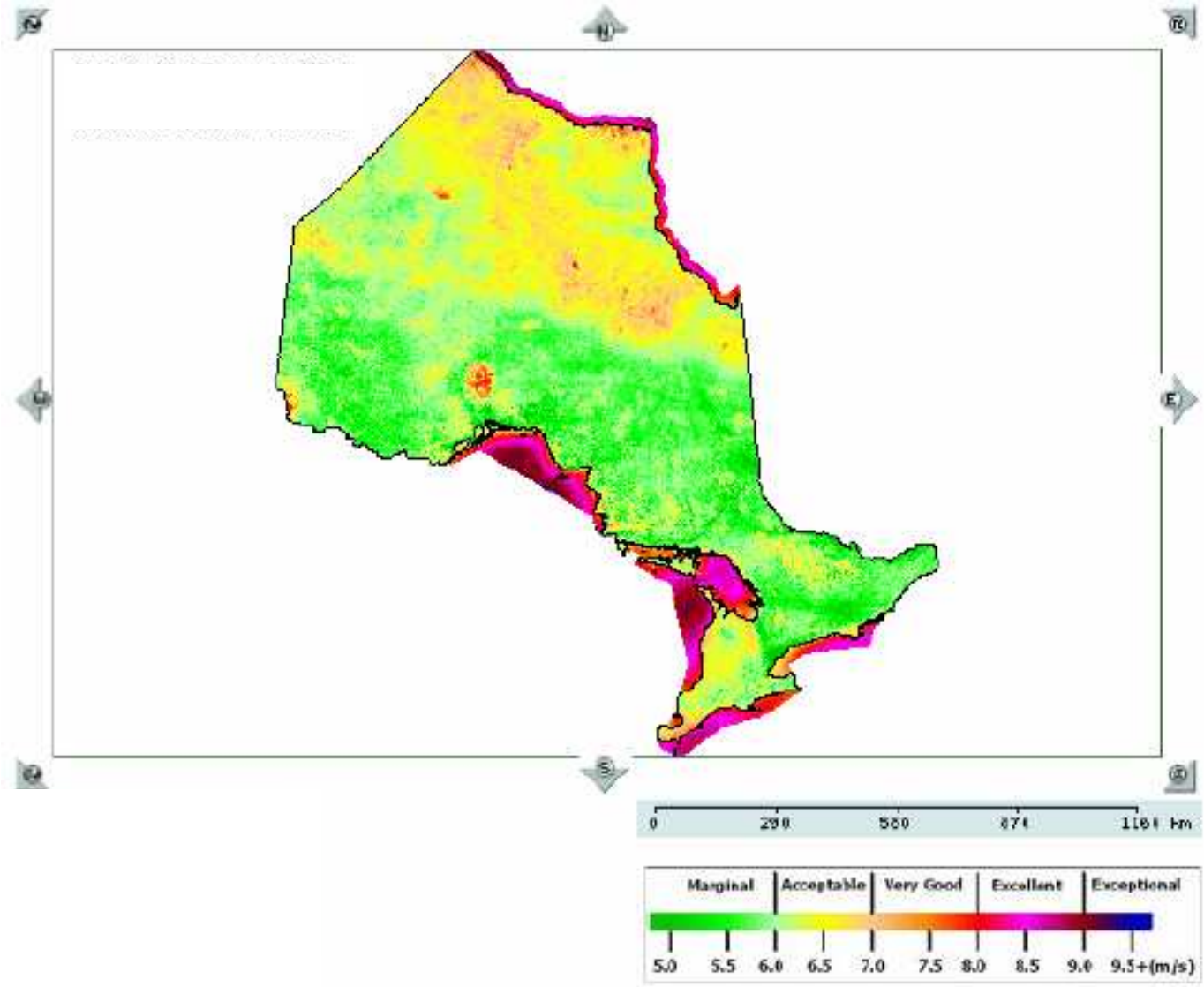
## Wind Speeds Considered

In general, Hélimax classifies wind speeds in by the following manner:

| Wind Quality | Wind Speed at 80 m |
|---|---|
| Exceptional | 9 m/s and above |
| Excellent | 8 to 9 m/s |
| Very Good | 7 to 8 m/s |
| Good | 6 to 7 m/s |

The Ministry of Natural Resources of Ontario has estimated that for a utility-scale project to be competitive it must be built in an area with wind speeds above 6.5 m/s.

## APPENDIX B: WIND RESOURCE MAP OF ONTARIO




*Source : Ontario Ministry of Natural Resources*

**Figure 1: Average wind speeds at 80m agl in Ontario**

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November 8, 2005

Mr. Amir Shalaby
Vice-President, Power System Planning
Ontario Power Authority

re: A Policy Framework to Support the Deployment of 6,000 MW of Wind Energy in Ontario by 2015

By Fax: 416 – 967 – 1947

By E-mail: amir.shalaby@powerauthority.on.ca

Dear Mr. Shalaby,

When the Canadian Wind Energy Association (CanWEA) met with the Ontario Power Authority (OPA) as part of the OPA's consultation process on the future supply mix for electricity in Ontario, CanWEA was asked to provide the OPA with information on the key policy issues that would need to be addressed if Ontario was to successfully implement CanWEA's recommended target of 6,000 MW of installed wind energy capacity by 2015.

CanWEA has polled its Ontario Caucus on this issue and we would like to take this opportunity to present an overview of the key policy challenges we believe need to be addressed in Ontario if the target we have proposed is to be met. Naturally, we would be happy to discuss any of these policy issues in more detail with the OPA once you have had an opportunity to review this submission.

Formally Establish a Wind Energy Target for Ontario

If Ontario wants to secure 6,000 MW of wind energy by 2015, the Ontario Government needs to enshrine this target in legislation. Doing so will provide a greater degree of certainty for all stakeholders and will reduce fears that investments may be stranded or devalued by future policy changes. It also will also send a clear signal and provide a strong driver for the other policy changes required to ensure the target is met.

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Allow the Market to Reflect the Real Cost of Electricity

CanWEA believes that it will be easier for governments to adopt aggressive wind energy targets if electricity markets reflect the real costs of electricity production – thereby increasing the competitive position of wind energy vis a vis alternative forms of electricity generation. This involves the gradual removal of price caps on electricity for consumers, market recognition of environmental externalities associated with electricity production, and an ability to market and sell green power.

Establish Procurement Policies that Ensure Sustained, Stable and Predictable Growth

CanWEA's submission to the OPA consultation on procurement mechanisms outlined our concerns about the Renewables RFP process used to this point and advocated a number of changes to that process. It also called for the adoption of Standard Offer Contracts as a complement to an improved RFP process in the short term.

The current RFP process promotes a "boom / bust" cycle of wind energy development in Ontario. While there is a "boom" in deployment after the awarding of each RFP, this is restricted to the winners of the RFP and no other deployment occurs until the next RFP process is completed. In addition, there is little clarity about future procurement processes – no one knows what is going to happen after Renewables RFP II and III have been completed.

Accordingly, CanWEA believes that Ontario must put in place a schedule of future RFPs that are designed to deliver a regular addition to Ontario's installed wind energy capacity on an annual basis (similar to the RFP process in Quebec). By taking action now to indicate how much renewable / wind energy Ontario plans to procure on an annual basis between now and 2015, Ontario will be making it easier for all stakeholders to plan and manage new additions of wind energy into the grid while also providing a stable market that will be more attractive for investors seeking to establish manufacturing facilities for wind turbines and their components.[1]

CanWEA is currently preparing a response to the OPA consultation document on Standard Offer Contracts. We believe it is important that Ontario, once it has gained some experience with Standard Offer Contracts, must seriously consider and assess the potential costs and benefits of applying this concept to larger projects both on and off distribution lines relative to a continued reliance on RFPs to procure power from larger wind energy projects.

[1] While this is a necessary condition to attract manufacturing, it may not be sufficient. The Government of Ontario should be proactive in seeking to create a more comprehensive set of policy supports to attract investment in wind turbine and component manufacturing to Ontario.

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Facilitate Wind Energy Deployment Through Short and Long-Term Transmission System Investments

CanWEA has provided the OPA with a copy of its submission to the Ontario Ministry of Energy consultation on transmission and distribution issues that took place in early 2005. Policy uncertainty in this area is one of the biggest barriers to expanded wind energy development in Ontario and the policy choices that are ultimately made in this area will go a long way towards determining whether or not Ontario can meet the 6,000 MW target.

The OPA will be developing a long-term transmission system plan for Ontario. CanWEA strongly believes that such a plan must ensure that the rate base supports proactive building of new, or upgrading of existing, capacity in areas that have a good wind resource and clear interest from wind project developers and other stakeholders. We also recognize, however, that it will take some time to develop such a plan. Accordingly, CanWEA also believes that the system must allow for proponent–led transmission investments that are covered to a pre-determined level by the rate base with the proponent responsible for any additional costs and interconnection charges.

All of this must be accompanied by much greater transparency about existing transmission capacity and planned additions and a simplified and standardized transmission interconnect policy and procedure.

Recognize the Benefits of Wind Energy in the Distribution System

Current distribution tariff policy often discriminates against wind energy and other forms of distributed generation. There is a need to adjust these policies to recognize and reward the benefits wind energy brings to the distribution grid (e.g., line loss reduction) and to facilitate access to distribution lines where capacity exists.

Streamline and Harmonize Municipal Permitting and Approval Processes

In the absence of Provincial guidance, municipalities across Ontario are developing unique municipal permitting and approval processes for wind energy projects that vary significantly from municipality to municipality. The result is an emerging patchwork quilt of regulations that creates an “unlevel playing field” for developers across the province and results in inefficiency and additional costs for all involved. Provincial guidance in areas like official plan amendments, zoning by-laws, land tenure length and site plan agreements would be very helpful.

Simplify the Environmental Assessment Process

While the Federal Environmental Assessment process tends to be more problematic than the provincial process, the provincial process should be streamlined (e.g., one window approach to review and approvals, “class” environmental assessments) and should also

allow some variability in environmental assessment requirements based on the scale of the project, including exemption from the process for some projects.

Support Human Resource Development and Training for Wind Energy

While some pilot programs are starting in Ontario, there is currently little in the way of post-secondary education and training programs designed to produce workers in the wind energy industry. This will be an issue in the future as the market grows.

Educate the Public and Stakeholders About Wind Energy

Where there has been opposition to wind energy projects, it is often based in misinformation or a lack of information about wind energy. There is also little understanding of the wind energy project development and approval process. By taking steps to ensure that all stakeholders are working from a similar and well-informed knowledge base, the Ontario Government could ensure that any concerns voiced about projects are based in "real" issues, allowing all stakeholders to invest their energy in finding solutions to those problems as opposed to addressing "red herrings".

Crown Land Allocation Process

Concerns are emerging about Ontario's Crown Land allocation process and CanWEA is working to develop a submission to the Ministry of Natural Resources that catalogues these issues and proposes solutions to address them. We will ensure you get a copy of this submission once it is completed.

Wind / Renewable Energy Secretariat

The creation of a wind energy, or renewable energy, secretariat within the government to coordinate all policy-making institutions and drive forward action in all of these areas would be extremely useful in ensuring these issues are addressed in a comprehensive and synergistic manner. Such a body could perhaps ultimately be supported by a more comprehensive and overarching legislative framework to support wind energy development in Ontario.

While there are a number of policy challenges that must be addressed if Ontario is to put in place 6,000 MW of wind energy by 2015, these challenges are not insurmountable. Indeed, many of them have already been considered and dealt with in other jurisdictions that are further along in wind energy deployment. With a clear target and a strong commitment to meet it, all stakeholders will have a common interest in working to address and resolve issues as they emerge.

It is clear that the OPA is an important stakeholder and will have a key role to play in determining the future role wind energy may play in Ontario's future energy supply mix. Accordingly, CanWEA would like to suggest the formation of a CanWEA / OPA "working group" that could both engage in a more detailed discussion and exploration of the policy barriers outlined in this letter and identify a range of potential actions to address those barriers.

Thank you again for the opportunity to provide you with this submission and we sincerely hope that it will provide the foundation for an ongoing dialogue between CanWEA and the OPA on the role wind energy can play in meeting Ontario's future electricity needs.

Yours sincerely,

Robert Hornung
President

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# Written Advise to OPA on Future "Supply Mix" for Ontario's New Renewable Energy Capacity

**Prepared By:**

**Martin Lensink, CEM Engineering**

**Prepared For:**

**John Kikkert, Christian Farmers Federation of Ontario**

**Date:**

**Friday, August 26, 2005**

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2. Benefits of On-Farm Anaerobic Digestion
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6. Current Capital/Operating Cost Data

# Introduction

- Methane gas will continue to be produced by agricultural activities
- It will either destroy ozone **OR**
- It can be captured and used to produce heat and electricity
- The Province of Ontario has Conservation & Renewables objectives
- Farmers in Ontario can help the Province achieve these objectives

# Principle of Anaerobic Digestion

- Manure & other co-substrates are inserted into a large sealed airless container
- In this oxygen free environment, bacteria produce biogas
- Contents are heated to accelerate the process
- Biogas can be used to generate heat or electricity or both

# Support For On-Farm AD's

- NRCAN
  - "Discover the Production and Uses of Biogas"
- Agriculture Canada
  - "Crop Nutrients, Swine Manure, Low Temp AD"
- Recent Federal Budget
  - Grant of 1¢/kW.h (Kyoto)
  - Increase Tax Treatment to 50% Declining Balance
- Ontario Ministry of Agriculture & Food
  - Paper By Don Hilborn (Off-Farm Organic Matter)
- Ontario Ministry of Energy
  - Conservation Action Team (#18)
  - Net Metering (50 kW to 500 kW)

# Background

- Presentation to OMAF, December 16, 2004
  - Sara Zippin, Don Hilborn
- Presentation to MOE, January 20, 2005
  - Marion Fraser
- Presentation to MPP Donna Cansfield, February 15, 2005
- Presentation to MPP John Wilkinson, March 21, 2005

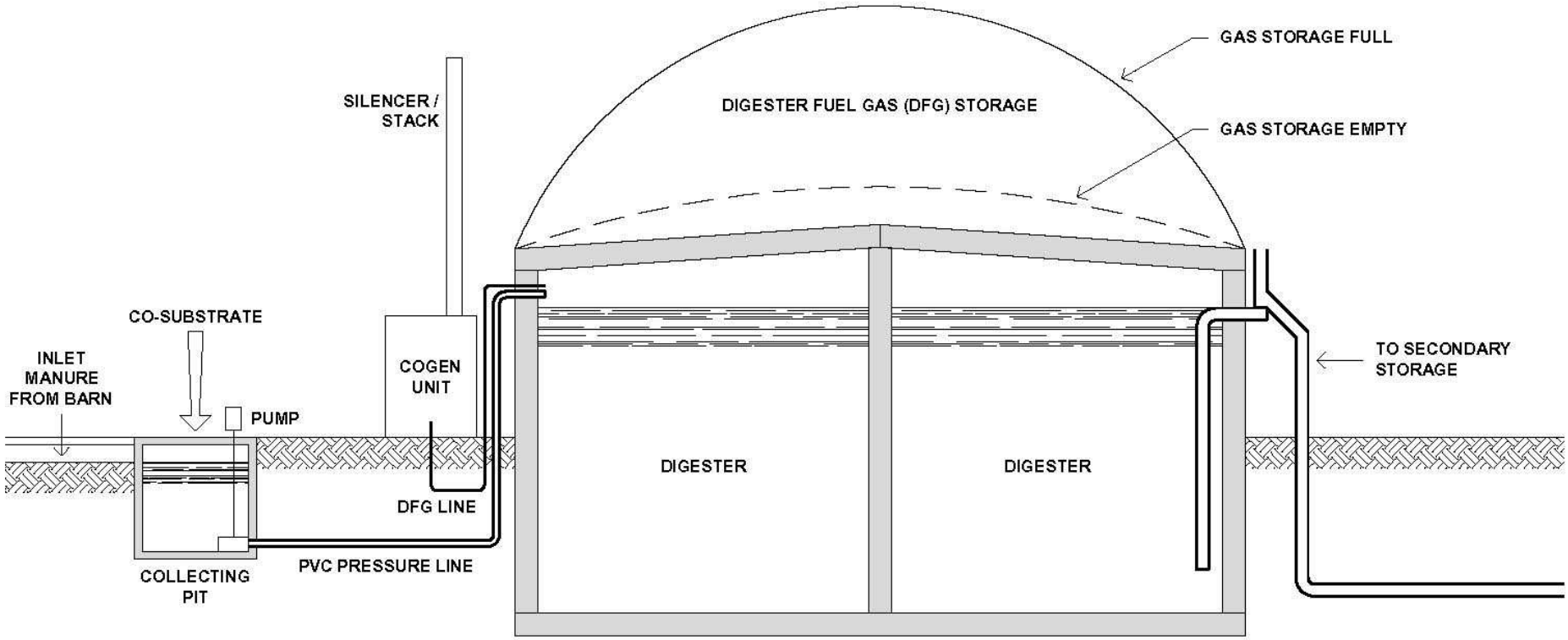
# Situation Analysis

- There is only one (1) on-farm AD operating in Ontario (another under development)
- AD has been in operation for several decades (proven technology)
- Commercially attractive way to produce renewable energy
- Thousands of farm-scale AD's operating around the world
- Methane gas can be stored on-farm during off-peak periods and electricity produced from it during on-peak periods
- Any farm producing at least 1,000 tonnes of manure per year would benefit economically by installing an on-farm AD
- The Province would realize important environmental benefits

# AD TECHNOLOGY TUTORIAL

- Simplified Flow Diagram
- Examples:
  - Vegreville, Alberta
  - Ribe, Denmark
  - Leeuwarden, Netherlands
- Case Study – Epping Farm, Germany
- Case Study – Klaesi Farm, Cobden, ON

# AD Schematic Diagram



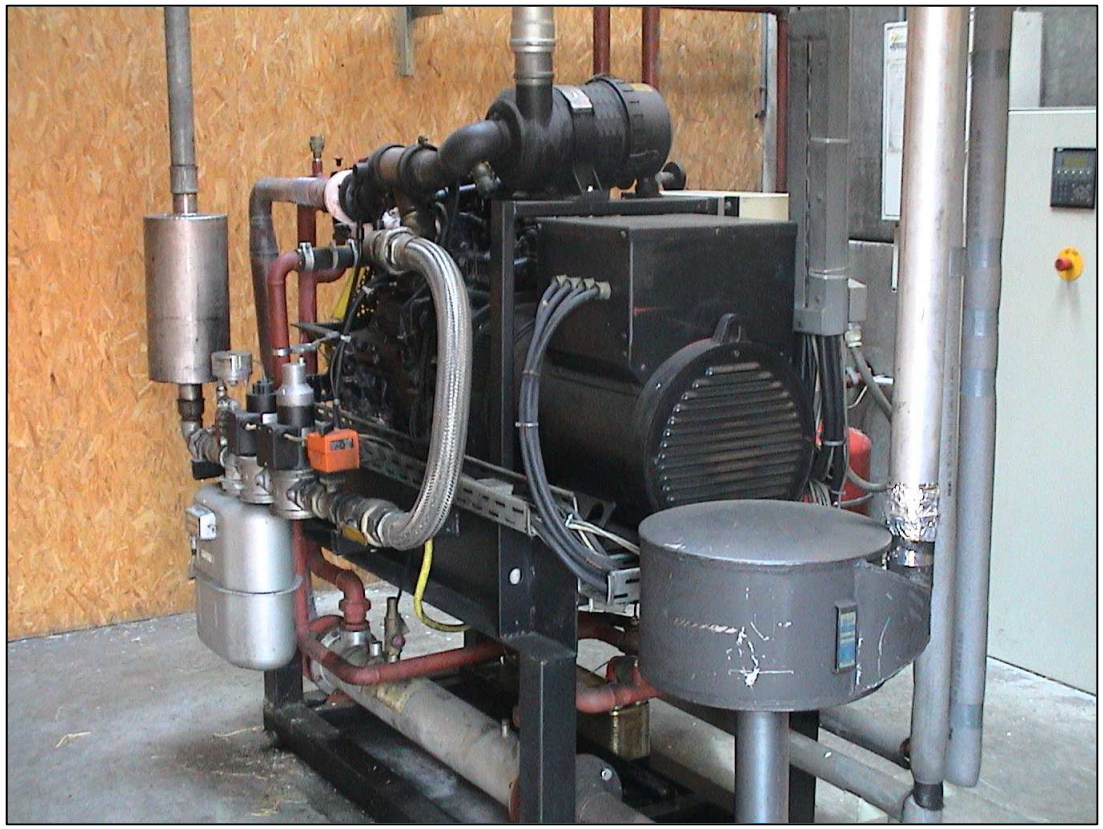
# AD Example – Vegreville, AB

- 60,000 head
- 2 @ 1,500 $m^3$ each
- 1,000 kW ICE

# AD “Co-op” – Ribe, Denmark

- Supplied from 69 farms
- 3 @ 1,745 $m^3$ each
- 400 tons/day manure

# AD Example – Leeuwarden, NL



- Cows (130 + 64)
- 900 tns/year
- 80 $m^3$ capacity
- 37 kW ICE

# Case Study – Epping Farm, Germany

# Case Study – Epping Farm, Germany

Corn Silage Substrate

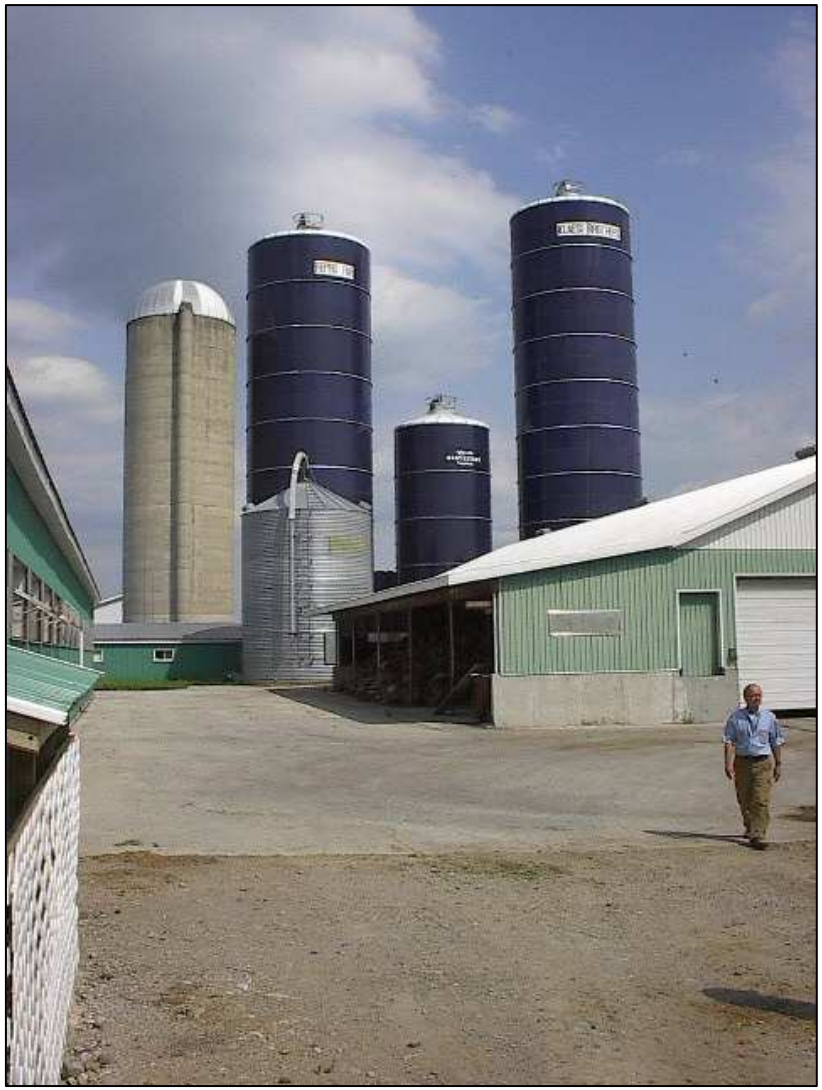
# Case Study – Epping Farm, Germany

- 80 kW Perkins ICE
- 95% biogas
- 5% diesel

# Case Study – Epping Farm, Germany

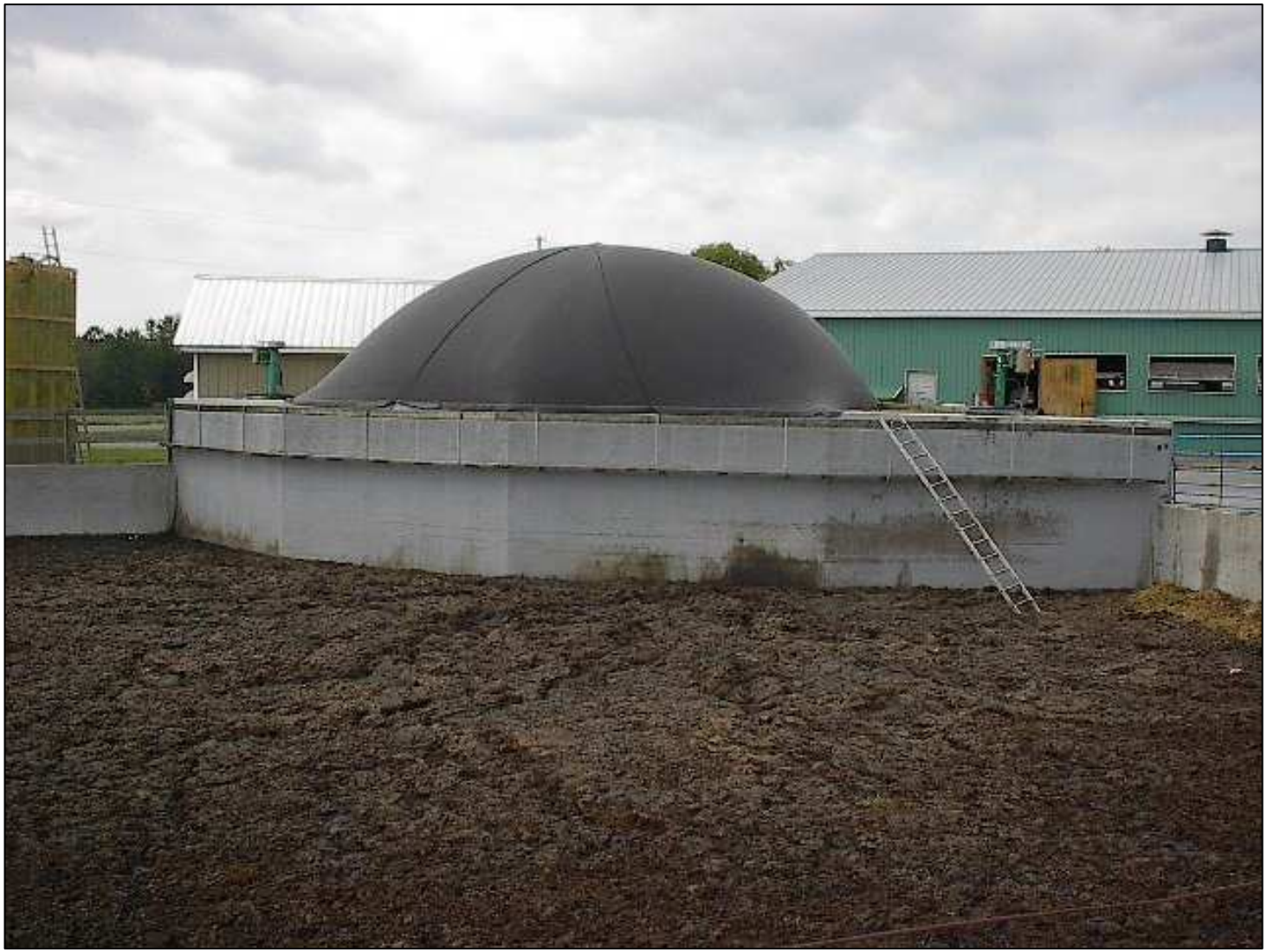
- Heat Recovered from ICE
- Jacket Water/Block (& Exhaust)
- Heat Manure to 38$^{o}$C (or 58$^{o}$C)

# Case Study – Klaesi Farm (Cobden)



- 200 Animal Units
- 12-15 $m^3$/day manure
- 400 $m^3$/day biogas

# Case Study – Klaesi Farm



# Case Study – Klaesi Farm

# Case Study – Klaesi Farm

- 65 kW ICE
- 50 kW net metering

# Case Study – Klaesi Farm

# Benefits of On-Farm AD to Farmers

- Elimination of pathogens in manure
- Destruction of weed seeds in manure
- Elimination of odours from manure
- Significant improvement to the profitability of farms in Ontario
- Improvement in the fertilizing qualities of manure

# Quantify Resource in Ontario

- Potential (MW) from Broiler Litter
- Potential (MW) from Dairy Manure
- Potential (MW) from Swine Manure
- Power (MW) Potential Summary

# Potential (MW) from Broiler Litter

# Potential (MW) from Broiler Litter

- 1,150 boiler producers in Ontario (CFO)
- 60,000,000 kg meat every 8 weeks
- 0.7 kg manure per kg meat (OMAF)
- 250,000 tonnes broiler litter per year in Ontario
- 200 $m^3$ biogas/tonne manure
- ICE uses 0.4 $m^3$ biogas/kW.h (65% $CH_4$)
- $125x10^6$ kW.h/year of electricity

# Potential (MW) from Dairy Manure

# Potential (MW) from Dairy Manure

- 400,000 dairy cows in Ontario (milk.org)
- About 6,000 producers in Ontario
- 22,700 kg manure/dairy cow/year
- 9-10 million tonnes dairy manure/year
- 28 $m^3$ biogas/tonne manure
- 0.4 $m^3$ biogas/kW.h (@ 65% $CH_4$)
- 630-715 x $10^6$ kW.h/year of electricity

# Potential (MW) from Swine Manure

# Potential (MW) from Swine Manure

- 5,370,000 hogs per year (ontariopork.on.ca)
- Hogs ship at 6 months
- 1,300 kg manure/hog/year
- 3,500,000 tonnes swine manure/year
- 25 $m^3$ biogas/tonne manure
- 0.4 $m^3$ biogas/kW.h (@ 65 $CH_4$)
- 220 x $10^6$ kW.h/year

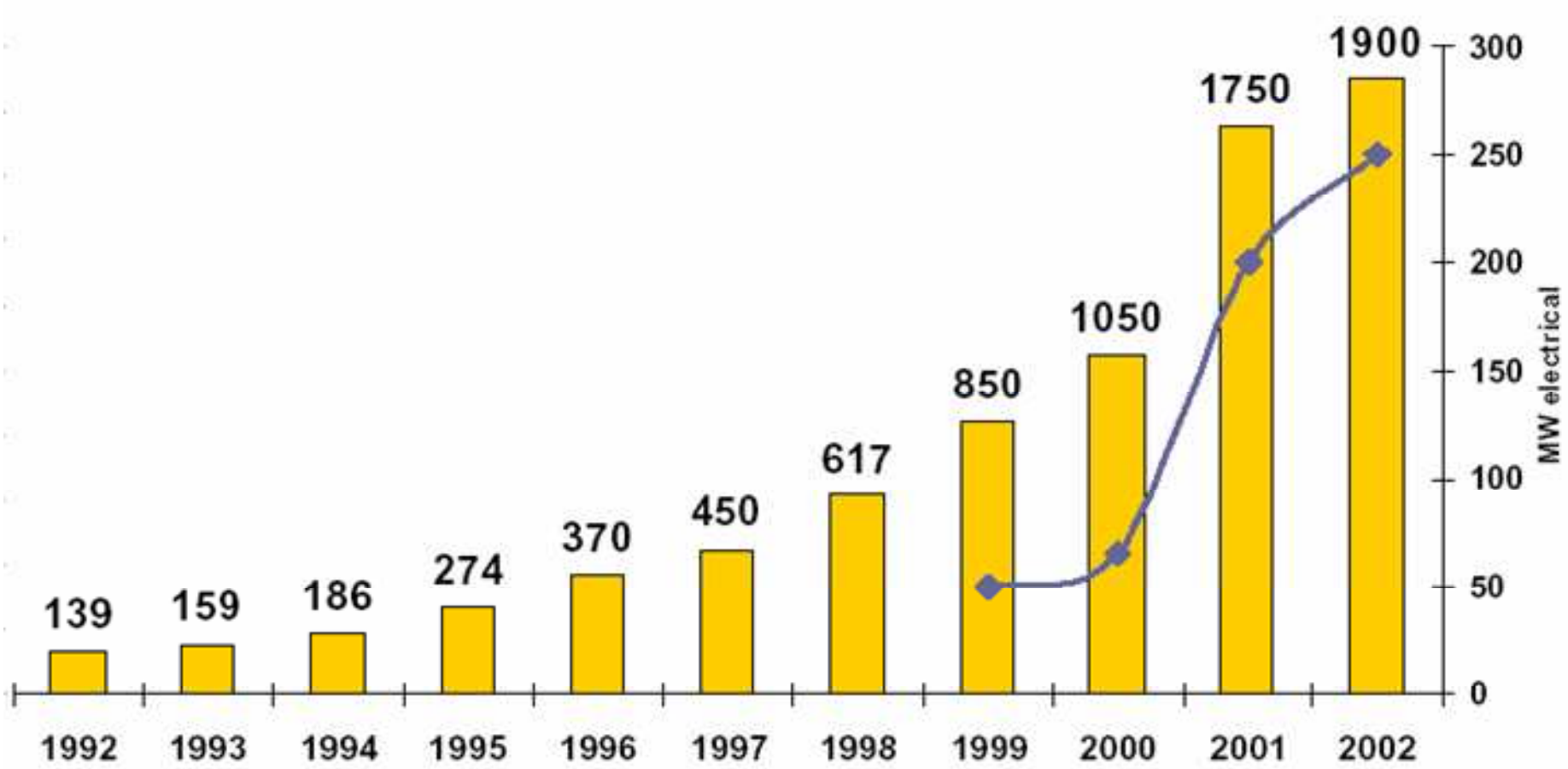
# Power (MW) Potential Summary

| Animal | Units | Power Generation |
|---|---|---|
| Poultry (Broiler) | $10^6$ kW.h/yr | 125-250 |
| Dairy | $10^6$ kW.h/yr | 715-2,860 |
| Swine | $10^6$ kW.h/yr | 220-880 |
| **Max. Total from AD** | **$10^6$ kW.h/yr** | **1,060-3,940** |
| Approx. Total | $MW_e$ | 123-469 |
| Approx. Total (AD) | TW.h/yr | 1-4 |
| Power Used (ONT) | TW.h/yr | 152 |
| **AD/Total** | **%** | **0.66-2.6** |

# Benefits of On-Farm AD to Government

- Reduction in $CO_2$ emissions by at least one million tonnes/year
- Achievement of 20% of Ontario's stated renewable power objective
- Production of enough electricity to supply 100,000 homes per year
- Reduction of reliance on fossil fuels such as oil, natural gas, and propane when heat is recovered
- Production of more organic fertilizer
- Creation of jobs, since a whole new industry is created
- Achievement of objectives of Ontario's Nutrient Management Act

# Development of On-Farm AD's in Germany from 1992-2002



# Price Paid For Power From Biomass* Projects in Austria, Germany**, & Spain

| | €cts/kW.h | CAD ¢/kW.h |
|---|---|---|
| Up to 150 kWe | **11.5** | 18.6 |
| Up to 500 kWe | 9.9 | 16.0 |
| Up to 5 MWe | 8.9 | 14.4 |
| From 5 MW to 20 MW | 8.4 | 13.6 |
| **Add**, if manure & plants are used | **6.0** | 9.7 |
| **Add**, if heat is recovered | 2.0 | 3.2 |
| **Add**, if catalytic converter used | 2.0 | 3.2 |
| **EX. 65 kW ON DAIRY MANURE** (with no heat recovery or catalytic converter) | **17.5** | **28.3** |

* In Europe, on-farm AD's producing electricity are included in Biomass

** Over 3,000 biogas plants now operating in Germany

# Example: Current Capital/Operating Cost Data

- 80 $kW_e$ Cogen & 570 $m^3$ capacity AD
- Capital Cost is $400,000 - $500,000
  - Depends on complexity of electrical interconnect
  - Depends on length of piping tie-ins
- Outputs are:
  - 673,000 kW.h of saleable electricity
  - 2,300 mmBtu/year of recoverable heat (hot water)
- Annual Operating Cost is $14,000/year:
  - Includes allowance for engine maintenance
  - Includes lube oil for engine

# Conclusion

To promote acceptance of and investment in on-farm AD's, we, the farmers of this Province:

- Need a policy decision by the Government of Ontario
- Do not want or need grants

# Conclusion

We do need these three (3) things:

a) Predictable price for Power
   - Makes initial capital investment economically attractive

b) Power Purchase Agreement
   - A contract for 20 years

c) Electrical Interconnect
   - Which is straightforward, known, and approved in a timely manner

# Impact on HOEP of Predictable Price for Power Made Via On-Farm AD's

| Average HOEP For Example ($/kW.h) | Market Share of all other Generators | Possible AD Price ($/kW.h) | Market Share of AD Power | Weighted Average Including AD | Impact on HOEP (%) |
|---|---|---|---|---|---|
| 0.0522 | 0.9934 | 0.15 | 0.0066 | 0.0528 | 1.2 |
| 0.0576 | 0.9934 | 0.20 | 0.0066 | 0.0585 | 1.6 |

This example presumes that all manure in Ontario is converted to electricity and 123 MW of new capacity is installed. We know that not every farmer will install an on-farm AD, even if the Standard Offer is excellent.

# Conclusion

We need the Ontario Power Authority to create a "STANDARD OFFER (FIXED PRICE) CONTRACT" which:

- Pays the right price (at least 13-15¢/kW.h)
- Is in effect for 20 years
- Has a simple/known interconnect

# CITIZENS FOR RENEWABLE ENERGY

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cfre@web.ca

Ontario Power Authority
Supply Mix Submissions
175 Bloor St. E., North Tower, Suite 606
Toronto,ON
M4W 3R8

August 01, 2005

Dear OPA,

we are happy to follow your invitation to submit a paper of recommendations regarding the Long-Term Supply Mix for Ontario.
Citizens For Renewable Energy(CFRE) is a not-for-profit organization incorporated in Ontario in 1996. We have presented previously before the MacDonald Commission in 1996, before the Select Committee on Alternative Fuel Sources in 2002 and submitted comments on Bill 100, The Energy Act.
Following the instructions provided we would like firstly to address the immense benefit of Conservation and Demand Side Management. It is a well-established fact that energy not consumed saves costly energy generation(NegaWatts), to the point where government or utility funds invested in conservation measures double the return financially received.
These measures would entail incentives to trade-in inefficient air conditioners, refrigerators, washing machines and cloth dryers against modern highly efficient ones. A new sector to recycle these old appliances would take care of materials that could be re-used, generating new job opportunities.
Government, institutional and commercial buildings should be encouraged to switch to energy-efficient lighting and on-demand switching.
Both of these initiatives would reduce grid demand by at least 20% over the next decade
(by 2015) if vigorously pursued.
The Pembina Institute study "Power for the Future"(2004),estimates that with the policy assumptions shown in their report (Minimum Efficiency Codes, Financial Incentives, Innovative Financing Programs and Fuel Switching) energy consumption could be reduced by 40% within 15 years from today's demand (page 16).
Conservation and Demand Management measures should receive the highest priority in OPA's short and long term supply mix because of their immediate benefits and low risk factor.
Assessing different supply technologies and resources for our province we must first entertain a comparison between large, centralized generation modes and smaller distributed energy generation.
The conventional way of centralized megaprojects is marked by its inefficiency by using

only limited portions of the primary power in the fuel (coal, uranium, natural gas) and needing large amounts of cooling water, producing thermal and air pollution, as well as leaving a legacy of toxic waste. Furthermore they are depending on high voltage transmission lines and also could be targets for terrorist action.
Distributed energy generators from renewable sources would need no manufactured fuel thereby not requiring steam-driven turbines and not leaving any waste. Gas-fired generators would be using the heat by-product in cogeneration modes and service large users directly thereby not being dependent on the transmission grid with its considerable line losses(up to 10%).
This comparison alone shows the major advantages of distributed energy generation, which should be used to favour this new form of power production over the conventional large, centralized mode.
While natural gas and coal gasification generators still use the steam-turbine method and those facilities take several years to be built, windenergy generators, geothermal heating and cooling systems, small run-of-the-river hydro-electric plants can be installed within 12 to 18 months.
The fact that these renewable energy generators rely only on nature for their fuel gives them the advantage to forego the usually substantial cost of manufactured and imported fuel. Cost of pollution prevention/abatement as well as waste management is also not a factor. The high up-front installation costs are in part due to having to import the components as there is a lack of Canadian manufacturers.
There should be no place in the future supply mix for nuclear power, not even for refurbishment of old nuclear reactors. Experience has shown that estimated costs have always been surpassed, often by orders of magnitude. The reliability of energy production expected has never materialized as components did not perform as designed and safety concerns required unscheduled shutdowns and repairs.
Taking externalities into account production costs of nuclear energy are much higher than natural gas cogeneration. A prominent research organization(OCAA) has estimated the Kilo Watt Hour costs of nuclear to be 10.7 cents kWh compared to natural gas of 6 cents and renewables of 8 cents per kWh.
New nuclear rectors would have a long lead time before producing power to meet Ontario's increasing demand.Taking the necessary assessment and licensing steps into account new builds would not contribute to Ontario's energy mix before 2015. And who would finance the Billions of dollars in cost? Ontario taxpayers/ratepayers? They already are having difficulty to pay off a more than 20 Billion dollar debt left to them from nuclear liabilities!
Nuclear waste safe keeping over many thousands of years is a costly and ethical dilemma and we should not add to it by perpetuating creation of this highly toxic waste!
**An ideal short time span solution for clean and safe power supply would be the procurement of a 100,000 Solar Roof Program. The contribution Solar-Photovoltaics(PV) can make has been largely overlooked. These systems installed on unshaded roofs in urban settings can contribute substantial amounts of power on high demand days and times when coupled with the right provisions for net metering.**
**The Ontario government has requested OPA to procure 500 MW of new supply to address the needs for Toronto as stated in the IESO's 10-year Outlook for Need of New Facilities. In the Pembina "Power for the Future" study Table 4.1 shows**

**estimates that a Solar Roof Program could reduce peak summer demand by 250 MW in 2010 and by 500 MW in 2015 - 10 years from now.**
**We feel that these estimates are overly conservative. With the right government support program like no- or low-interest loans and rebates coupled with a Standard Offer Contract(SOC) for buy-back of surplus power at favourable rates, private investment would finance these renewable energy, locally installed systems by a substantial number and over a shorter time span.**
**If government support would be shifted from nuclear plant refurbishment to solar power generation the benefits would be immense! Not only would the supply problem be eased because of the long life span of PV panels and solar roof tiles, but there would be a substantial increase in jobs created and the possibility of private investment in the PV manufacturing industry could not be discounted.**
**The contribution solar water heating systems can make to reducing energy demand must also be taken into account. As electric water heating consumes up to one third in household energy use the promotion and support of installing these passive solar systems, which have been vastly improved in their efficiency, on domestic, commercial and industrial buildings must be a high priority.**
We would like to echo the 10 policy recommendations for Ontario as proposed in the Suzuki Foundation Report(2004),Page 15,Executive Summary, especially Recommendation #7, “Collaborate with the federal government to establish a provincial revolving loan fund to provide interest-free loans to install renewable energy systems on farms, and in residences and businesses.

**Demand reduction equals energy conservation and must have a high profile in the Ontario Power Authority’s future supply mix plans.**
**These two Solar Initiatives would count as the lowest cost, lowest risk, shortest time span efficient sources of demand reduction in a new long-term energy for Ontario!**

**On behalf of the members and directors of Citizens For Renewable Energy(CFRE) submitted by**
**S.(Ziggy) Kleinau, Coordinator, CFRE.**

CAE Alliance
Box 931
Corunna, Ontario
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August 25, 2005

Ontario Power Authority
Supply Mix Submissions
175 Bloor Street East
North Tower, Suite 606
Toronto, Ontario
M4W eR8

Via Email:supplymixsubmissions@powerauthority.on.ca

To Whom It May Concern:

The CAE Alliance is a newly formed ratepayers group that represents a varied, and growing number of residents, workers and businesses in our province. The Clean Affordable Energy Alliance appreciates the opportunity to provide input into the supply mix for power generation in the Province of Ontario, and applauds the OPA directive requesting public recommendations.

We believe that the power generation situation in our province is at a critical phase of restructuring to meet growing demands, environmental goals and affordable costs for all electricity consumers in Ontario. Clean, affordable and reliable energy is vital for commercial viability and for sustaining the quality of life we enjoy in Ontario.

Part 1 of the CAE Alliance submission to the OPA addresses areas of concern, and suggests parameters and conditions for OPA to consider when determining the appropriate supply mix for Ontario.

Part 2 of our submission summarizes our recommendations with respect to the electricity supply sources.

## PART 1

1. The OPA must obtain scientific and environmental data from credible sources, well educated and highly respected in their fields of study. The OPA should be suspect of any information from self-interest groups with exaggerated, inflated claims.

2. The OPA should seek expertise from qualified members of the energy community who are knowledgeable about **all** fuel types. International sources, such as CERA and the IEA

(International Energy Association, of which Canada is a member), and fellow US and Canadian government agencies have a wealth of unbiased, independent information.

3. The OPA must consider the full lifecycle of the fuel source when addressing the environmental ramifications, and weigh all factors before long term decisions are made.

4. All existing and developing technologies must be considered without bias, where significant emissions reductions can be obtained. It is the responsibility for the Ministry of Energy, and the OPA, to determine energy policy for the province. It is the responsibility of the Ministry of the Environment to set emissions controls and limits for all industry in Ontario. The Ministry of Energy should consider all available generating sources provided they meet MOE emissions targets.

5. The mandate of those planning for the future of provincial power, as stated in Bill 100, is to "protect the interests of consumers with respect to prices and the adequacy, reliability and quality of electricity service." The OPA must make decisions for the future electricity supply without negatively impacting the economy of Ontario. Stability of fuel cost and supply will determine future pricing.

6. The ECSTF (Electricity Supply and Conservation Task Force) was commissioned to "develop an action plan to address the province's need for an affordable, reliable and environmentally acceptable power supply over the period to 2020." The ECSTF spent considerable time addressing submissions from many groups with vested electricity needs and interests, as well as many energy experts. The OPA should reconvene the ECSTF and request their assistance in determining future supply mix, without restriction or bias as to fuel source.

7. The CAE Alliance believes that the OPA is in an unenviable position of fulfilling its "mandate of long-term power system planning" relating to the adequacy and reliability of electricity supply, while being constrained by the existing government's mandate to phase-out coal-fired generation in the province. It is difficult to plan 20 and 30 years into the future for a vital service of life, when we are 2 years into a 4 year government term. Therefore, it would be prudent for the OPA to consult with opposition energy critics when determining future energy policy.

8. Historically, Ontario has benefited from having a diverse portfolio of energy sources that, combined, provide reliability and stability for baseload, intermediate and peak load conditions. This has translated into secure, affordable electricity. It is imperative that the diversity of supply mix be maintained.

9. Significant changes have occurred over the past 5 years that directly impact our energy choices. These include rising and volatile costs of natural gas; concern over dwindling gas supplies; advances in emissions technology, that are proving to be effective; the California power crisis and resultant shift in financial decisions. This has caused many to rethink deregulation. World political events are causing hesitation in proceeding with electricity fuel sources that would result in the further dependence on foreign sources. These factors that impact choices for supply mix have accelerated in

importance since the current Liberal government first determined to remove coal-fired generation from the provincial power supply.

10. With consideration to the events noted above, it is imperative that the OPA consider fuel choices that maintain Ontario's self-sufficiency with respect to electricity generation.

PART II – RECOMMENDATIONS FOR SUPPLY MIX

1. Nuclear currently provides more than 36% of the provincial power. OPG has determined not to proceed with the further refurbishment on the remaining Pickering A units. Therefore, we would encourage the OPA to actively pursue new nuclear facilities. For environmental and safety reasons, we would encourage the OPA to direct OPG to maintain it's role as provider and maintainer of nuclear power, with increased oversight into cost issues. As nuclear units take approximately 10 years to bring on line, the OPA should proceed with this option without delay.

2. Credible Canadian, US and international government and energy market information indicates that current natural gas supplies are declining. The US Department of Energy informs us that Canada's proven natural gas reserves will be depleted in 8.6 years at current consumption. Rising demand is outpacing supply. New sources are not producing at the rate of old. Unconventional sources come with a high price tag, both commercially and environmentally. The National Energy Board advises that gas consumption in Ontario would increase 5 fold to replace coal generation.
In addressing the demand aspect of natural gas, The National Energy Board addresses the issues and costs associated with energy alternatives to natural gas, **alternative methods** of electricity generation, including clean coal.

3. Supply and demand issues are creating a high and volatile market outlook for natural gas. The price, according to the US government, has tripled in the past 4 years, without any foreseen alleviation. The ECSTF indicates that "the potential economic impact of a major increase in dependence on natural gas fired generation is magnified by the ongoing volatility in gas prices and growing concern about the availability of affordable natural gas supplies over the next ten years."

4. The CAE Alliance recommends keeping coal fired generation in the provincial mix, with significant upgrades in emissions technology. The 2 units at Lambton Generating Station retrofitted with clean air technology have proven effective in emissions reductions, almost within those of natural gas. The abundant supply of affordable coal, together with coal generation's capacity to supply base, intermediate and peak load power at very short notice, ensure coal's place as the stability in the power grid.

The Canadian Federal government indicates that we now have the technology to make clean coal a reality. (Natural Resources Canada)
The International Energy Association, or IEA, of which Canada is a member states the following, "Coal makes an important contribution to the economic and social pillars of sustainable development and its environmental performance has improved steadily.
Faster and more dramatic improvements in environmental performance are feasible now

and should be high priorities of industry and government to ensure coal's contribution to sustainable development.
Governments should recognize that coal will continue to play a major role in world energy supply for many decades to come. "

5. Coal related technologies are rapidly advancing. There is a wealth of information about coal gasification and carbon sequestration, which should be fully investigated and included in the future supply mix. Ontario can be a world leader in terms of technological advances.

6. The lifecycle of fuel source, obtaining and transmitting, as well as combustion, must be considered when reviewing environmental concerns. Regarding Kyoto Protocol requirements, it should be noted that natural gas emissions of CO2 on a national level are higher than for coal. Also, natural gas is 75% methane, and methane gas is 20+ times more potent a greenhouse gas than is CO2.

7. Increased use of renewable energy has been encouraged through the RFP process. However, private investment in North American technologies is limited to little other than wind power, which is not a reliable source. Environmental concerns regarding the impact on bird and bat population are just beginning to become known. The OPA must initiate development of other sources of renewable energy such as peat, biomass, etc., which are in greater use in other countries. It is likely that public funding, ie through OPG will be required. We have the expertise in our province to move forward in energy sources for the future. Relying on private investment will result in limited renewable resources available to Ontario.

Finally, with respect to conservation targets, the CAE Alliance would encourage the OPA to reconsider the Smart Meter proposal. The cost for these meters will dip too deep into the ratepayer's pockets. The Ontario public response to concerns during the summer shows how effective a public appeal can be. Broaden that concern to year round consumption and the public will respond.
The California government provided positive incentive for power resourcefulness by granting rebates for those customers who reduced consumption by 20% over the summer months. It has proven effective and encouraged a cooperative response from the public.
Stores, malls and restaurants continue to be overly cool during the summer. They must be encouraged to reduce air conditioning to a comfortable, responsible levels.

At this critical time of energy restructuring in Ontario, we need more, not less power. The reserve capacity must be increased to a more comfortable level. The Ontario power grid was strained more than 50 times during this summer. We imported a significant amount of power at a premium price. The OPA must act quickly, but wisely in order to set in motion the process to secure power for our future – power that is affordable for all ratepayers, allows business and industry to remain competitive, and is environmentally sound.

We trust that you will consider our input.
Carol Chudy & Susan Grant, Co-Chairs, CAE Alliance

SEP 1 4 2005

**Minister of Energy**
Hearst Block, 4th Floor
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Toronto ON M7A 2E1
Tel.: 416-327-6715
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**Ministre de l'Énergie**
Édifice Hearst, 4e étage
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Ontario

c.c. P. Bradley
c.c. A. Shalaby

AUG 3 1 2005

COPY

Mr. Gordon A. Robb
President, CogenCanada
1855 Beattie Avenue
Ottawa, Ontario
K1H 5R7

Dear Mr. Robb:

Premier Dalton McGuinty forwarded your letter regarding opportunities for co-generation in Ontario. I am pleased to respond.

The Ontario government shares your views on the benefits of co-generation. Industrial co-generation projects provide industry with a concrete means of controlling electricity costs and steam/heating requirements and consequently providing regional and employment benefits by making existing industry more viable.

As you may know, the government has directed the Ontario Power Authority (OPA) to begin the process of acquiring new generation and demand management projects, including up to 1,000 megawatts of high efficiency combined heat and power projects across Ontario, including industrial co-generation. I expect this process to be launched no later than the fall of 2005, with the subsequent contracting starting in early 2006.

We have heard from a number of companies and industries that are energy intensive and have the potential for the development of additional co-generation capacity.

.../cont'd

I have taken the liberty of forwarding a copy of CogenCanada's submission to Mr. Jan Carr, Chief Executive Officer of the OPA , for his information. Thank you again for taking the time to bring your views to my attention and please accept my best wishes.

Sincerely,

Dwight Duncan
Minister

c: The Honourable Dalton McGuinty, MPP, Ottawa South
Jan Carr, CEO, Ontario Power Authority

MC-2005-3052 C: Jana Alana

MCO

(MMC) PC – Premier's constituency office forwards letter from Cogen Canada re: criticism of recent RFP for Sarnia replacement generation, suggestion for Co-generation

S – Cogeneration

X-ref: MC-2005-2260

**Dalton McGuinty, M.P.P. / député**
Ottawa South / Ottawa-sud
Ontario

The Honourable Dwight Duncan
Minister of Energy
Ministry of Energy
900 Bay Street, 4th Floor
Hearst Block
Toronto, Ontario
M7A 2E1

July 26, 2005

Dear Minister Duncan:

Please find enclosed a letter from a constituent, Mr. Gordon Robb, regarding energy generation options. I believe that his comments and suggestions will be of interest to you and those in your Ministry.

Thank you for your consideration.

Yours truly,

Dalton McGuinty, MPP
Ottawa South
Premier of Ontario

Cc: Mr. Gordon Robb

Encl: Letter from Mr. Gordon Robb
Letter of response

RECEIVED
CORRESPONDENCE CONTROL UNIT
AUG 3 2005
ENERGY
ONTARIO MINISTRY OF ENERGY

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Dalton McGuinty, M.P.P. / député
Ottawa South / Ottawa-sud

Mr. Gordon A. Robb
President
CogenCanada
1855 Beattie Avenue
Ottawa, Ontario
K1H 5R7

July 26, 2005

Dear Mr. Robb:

Thank you for your letter regarding options for electricity generation. I value your views and am grateful to you for taking the time to share them with me.

Energy is vital for quality of life and economic prosperity in our province: it is essential to almost every aspect of our lives. This is why ensuring affordable, reliable and clean electricity is one of our government's priorities. We will deal with electricity issues in a practical, transparent and sensible way, and ensure a safe, reliable and sustainable supply of energy for the people of Ontario.

I appreciate the issue you raised. As it would best be addressed by the Honourable Dwight Duncan, Minister of Energy, I have asked him to respond to you directly. I am confident Minister Duncan's response will shed more light on your specific concerns.

Thank you again for taking the time to share your thoughts with me. Your input on any provincial issue is always welcome. My colleagues and I look forward to continuing to work with you and your fellow Ontarians to meet your priorities and deliver the results you deserve.

Yours truly,

Dalton McGuinty, MPP
Ottawa South
Premier of Ontario

Cc: The Honourable Dwight Duncan

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**CogenCanada**
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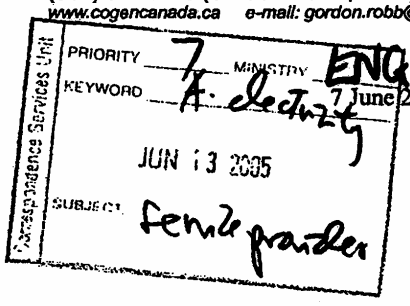


7 June 2005

The Honourable Dalton McGuinty
Premier of Ontario
Legislative Building
Queens Park
Toronto ON M7A 1A1

Dear Mr. McGuinty

**Subject**:-Selection of Ontario Electricity Generation Options. The case for a number of reasonably large, flexible Natural Gas Combined Cycle Cogeneration systems serving Eco Industrial Networks. The case against large single purpose Combined Cycle power plants with no cogeneration component such as the two selected for the Sarnia region in response to the Ontario Electricity RFP.

This attached submission reflects the opinions of authorities on natural gas supply, thermal power generation, electric utilities, industrial cogeneration, industrial energy utilization, Eco Industrial Networks, nuclear power and the impact of energy costs on industrial competitiveness. Single purpose thermal electric power plants including the two selected for the Sarnia region reject between 65% and 55% of the fuel heat to the environment - it is wasted. Cogeneration plants use this heat for useful purposes such as product drying, chemical processing, food precessing etc. or space heating. In the cases of the Toronto Paperboard mill and the Mississauga paper mill mention in the submission, it is used for paper drying.

Many promoters of cogeneration argue for small efficient systems. The case for the larger natural gas combined cycle cogeneration systems which can make a major contribution to electrical supply is developed in the submission. We encourage nuclear cogeneration as existed at Bruce for two decades.

While I am submitting this as President of COGENCanada, our home/office is on Beattie Ave., a few blocks from your Kilborn Office. I have earned a living as an Energy Advisor for more than half a century in both public and privates sectors and have worked with th authorities mentioned in the first sentence.

Yours truly

Gordon A Robb

Gordon A Robb
President, COGENCanada

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Note - COGENCanada's target membership includes thermal power generators both fossil and nuclear, industrial steam users, utilities, related service providers and interested government groups. It is in a formative stage and cannot yet claim to represent a large number of members. It is a federally incorporated not for profit organization with a board of advisors with strong expertise in industrial energy, utilities, fuels and cogeneration (CHP). For more see www.cogencanada.ca

# COGENCANADA SUBMISSION TO THE GOVERNMENT OF ONTARIO

June 2005

**Subject**:-Selection of Ontario Electricity Generation Options. The case for a number of reasonably large, flexible Natural Gas Combined Cycle Cogeneration systems serving Eco Industrial Networks. The case against large single purpose Combined Cycle power plants with no cogeneration component such as the two selected for the Sarnia region in response to the Ontario Electricity RFP.

The plants selected would be in the Sarnia region but not within reach of existing steam users. North American natural gas production can no longer be maintained. Natural gas prices in North America have doubled over the past few years as a result of too many large single purpose combined cycle power plants. Liquid Natural Gas will start to help balance supply and demand in three or four years. However, world wide demand and time required to build liquefaction facilities will limit supply.

An LNG import terminal is under construction at Point Tupper Nova Scotia and others are planned. In the words of a leading authority ".....more attention needs to be paid to LNG supply since that rather than (import) terminal capacity, is likely to be the constrainig factor.....over the remainder of the current decade". The problem is the time required to build liquifaction facilities.

Single purpose fossil fuel thermal electric power plants reject from 65% (steam electric power plants) to 55% (combined cycle power plants) of the fuel heat to rivers, lakes, the ocean or the atmosphere. They should be co-located with processes using heat. Most of the heat rejected by the power plant can be used in processes such as paper drying, chemical processing, food processing or space heating. This is key to maximizing industrial competitiveness and minimizing environmental impact.

**Industrial Competitiveness**

In each case the steam user would enjoy enhanced competitiveness and less risk of down time. This is particularly important in Canada where due to the cold climate, industries must heat process air and water to summer temperatures in winter. This puts Canadian industries such as pulp and paper mills at a disadvantage compared with competition in warmer

climates such as southern USA.

**Economies of scale** in both capital and operating cost argue for reasonably large, flexible natural gas combined cycle plants with a cogeneration component. The cogeneration component should be base loaded. The non cogeneration component "firms up" electrical output and provides economies of scale. It also provides peaking power and spinning reserve. Without it a cogeneration plant could be very efficient but if the electrical output depends on the process heat requirement, the electricity revenue per kWh would be much less.

These two component combined cycle cogeneration plants would be up and running twenty four hours per day with the cogeneration component base loaded. The other component would provide peaking power and spinning reserve as required.

If the recent RFP result is any indication, the current Ontario Policy appears to be diametrically opposed to the approach advocated in this. These combined cycle plants should have been located near steam users and there should be a cogeneration component. There are such opportunities in the Sarnia region.

As noted, economies of scale in capital and operating cost with other considerations argue for flexible natural gas combined cycle plants with a cogeneration component. The 400 MW TransAlta plant now operating in Sarnia is an example of the right approach. This system serves four major steam users, Dow, Bayer, Suncor and Nova. Another example is the TransCanada cogeneration plant being built in major industrial park in Becancour to supply power to Hydro Quebec. It will also supply thermal energy (steam heat) to industries in the industrial park.

In the Becancour case the selection was by Hydro Quebec Engineers, some trained by our people. We have also trained and advised TransAlta Northland Power and TransCanada, good Canadian Companies whose investors receive dividend tax credits. That Hydro Quebec RFP did not specify cogeneration but it was a key consideration in the selection. A more recent RFP did specify cogeneration with a predetermined efficiency. The problem with that is that it limits the size of the plant. The federal incentive limits the capacity of the plant for a given process steam flow. There should be an incentive to include a cogeneration component in a larger plant.

**Hydro Quebec Policy**

Another interesting Hydro Quebec Policy has led to a number of good biomass cogeneration systems. Industrial electrical rates are not high enough to justify steam users investing in cogeneration systems. Hydro Quebec solved that problem by offering long term contracts to buy the entire output of good steam user owned biomass cogeneration systems at avoided cost (about 6 cents per Kwh). The steam user continues to buy electricity from Hydro Quebec at the low industrial rate (perhaps 3 to 4 cents based on the Hydro Quebec average cost). Hydro Quebec has a great deal of Hydro capacity built at yesterday's cost. The average cost is low. They will do the same for good gas turbine combined cycle cogeneration systems and IPP owned systems. Ontario should consider a similar arrangement. It should apply to existing recently installed steam user owned cogen systems.

The Ontario Power Authority should undertake to **meet the Revenue Requirements** of thermal power generators **only if they include a significant cogeneration component.** use waste or use byproduct fuels.

The Ontario RFP should have required a cogeneration component. The firms bidding would then be required to find a steam user partner or partners who would help screen prospective generators. In general the generators (likely IPPs) do not know much about the steam using processes. The steam users tend not know much about cogeneration. This is particularly true of natural gas combined cycle cogeneration.

There is a strong case for the steam users having an equity position in the cogen system if it is mainly owned by an IPP. The plants in Whitby ON and Joffre AB are examples. In the Joffre case where Nova Chemicals is the main steam user Nova has an equity position, there are Nova people working in the ATCO managed Cogeneration plant.

**Cogeneration Based Eco - Industrial Networks** - right road to industrial development

Cogeneration plants should be located near groups of steam using processes. This provides more economies of scale. With the appropriate arrangements for islanding, the cogeneration system and the steam users can continue to operate during grid failures. This Eco - Industrial Network approach is the right road to sustainable industrial development. It is strongly supported in the United States and Europe. In the US, the President's Council on sustainable development is promoting the concept to help create and maintain jobs. Output and waste from one process become inputs to other processes

**Electrical system planners should work with industrial development planners.** The cogeneration plant should be part of a utility center providing services to industries grouped within the park. New processes need not invest in utilities. District heating and cooling can be supplied to industrial and commercial buildings nearby. All new thermal power plants should be within two kilometers of steam users. The ideal is to be adjacent to at least one of the steam users.

This approach to adding electrical generation capacity will not only help maintain the viability of existing industrial establishments, it will help attract more. The cogeneration system should act as a utility center providing electricity, thermal energy and other services at lower cost. Proponents of new processes need not invest in utilities.

In 1997 ThermoShare, the Alliance of Energy Consultants now forming the Board of Advisors of COGENCanada did a study for the Federal departments of Environment Canada, Industry Canada and NRCan. While this study is somewhat out of date it remains useful. The Title is Integrated Eco Industrial Parks with Cogeneration, Energy Cascading and Recycling. We did mini studies (with the help of other consultants) of some 48 sites across Canada. Seventeen are in Ontario - Sault St Marie; Haldiman-Norfolk-Nanticoke; Cornwall(2 sites); Durham, Whitby Darlington; (2 sites); Cardinal; Windsor (2 sites); Thunder Bay (3 sites); Belleville (2 sites); Kingston; Sarnia and the Bruce Energy Center. We have done a good deal of study of an opportunity to build a cogen plant in Ottawa to supply three paper mills, two in Gatineau (Hull) and one in Ottawa.

Other studies of Sarnia were done for Manfred Klein of Environment Canada so we did not spend much time on Sarnia at that time. Our group does have a good knowledge of the Sarnia region.

**COGENCanada has a detailed data base** of steam users, cogeneration systems and thermal power plants in Canada including Ontario. This and the 1997 ThermoShare study should be useful to the Cogeneration Facilitator.

Recent increases in natural gas prices have caused many industrial plants, mills and institutional steam plants to use residual fuel oil (Heavy Fuel Oil referred to as HFO or bunker C) instead of natural gas. This fuel contains sulphur, so harmful sulphur compounds are emitted. Burners for residual oil are such that much more nitrogen oxide is emitted than with a modern natural gas burner. All this causes smog.

The solution is to install natural gas, gas turbine cogeneration at the industrial and institutional steam plants. This ensures that clean fuel will be used. With natural gas, gas turbine combined cycle cogeneration systems, natural gas will be used almost all the time. Propane or light fuel oil (no 2 oil) may be used some of

the time but these fuels cause much less pollution than does residual fuel oil. HFO is a residual which must be disposed of by the refiners. They sell it at less then the crude oil price.

The refiners should gasify the residual producing hydrogen to be used to fuel combined cycle cogeneration systems at the refineries. There are a number of such installations in other countries.

This has been discussed at length with Joe Zanyk, a member of COGENCanada's board of advisors and a leading authority on natural gas combined cycle cogeneration. He is a resident of Sarnia where he was responsible for creating Canada's first combined cycle cogeneration plant in the early seventies to serve the Dow Chemical Complex. Dow led the world in terms of gas turbine combined cycle cogeneration. For decades Joe was Dow's top technical person world wide. He is now an active combined cycle consultant and member of the Sarnia Chamber of Commerce Energy Committee

Joe Zanyk tells us that the Sarnia region sites selected for the two projects recently selected have not allowed for a cycle to make cogeneration viable. The capacity of the two plants selected could have been provided by a number of flexible combined cycle cogeneration plants located near the existing petrochemical plants. For example, eight 200 MW combined cycle cogeneration plants with extraction condensing steam turbines to provide firm power, peaking power and spinning reserve as well as process steam heat would yield far more benefit. We are aware of two ideal 200 MW cogeneration proposals, one for the Norampac paper mill in Mississauga and one for the Cascades Paper Board mill in Toronto.

**Natural Gas Supply Limitations**

Recent National Energy Board publications underscore Canadian natural gas production limitations. It is widely held that Liquid Natural Gas will balance natural gas supply and demand in North American in the future. COGENCanada is involved in a study of the impact of an LNG import terminal under construction at Point Tupper. Many communities have rejected these. Consequently

According to LNG Observer, an insert in Oil and Gas Journal, an authoritative publication, supply limitations due to the time required to build liquefaction facilities will be the constraint for the next decade. Europe including the UK and China are becoming major LNG importers. Japan depends on LNG. While prices in these countries are lower than in North America, they have recently increased significantly. LNG will have some moderating effect on NA prices but not enough to weaken the case against single purposes natural gas combined cycle power plants. A proliferation of such plants in the United States is widely considered to be the cause of recent drastic increases in the price of natural gas in North America

To consume the natural gas resources in the planned gas turbine combined cycle plants at the low efficiency of 43 % (HHV) to 45% (HHV) will put unnecessary upward pressure on natural gas and electricity prices. This will have an adverse effect on the economy.

If natural gas is to be used to generate electric energy it should only be used in a Co-generation cycle . In that cycle electricity and thermal energy such as steam is produced at a cycle efficiency of 75 % or better. With both electricity and thermal energy being produced by the same system there is the problem of allocating fuel to electricity and fuel to steam heat.

The traditional way of doing this is to deduct from the total fuel used by the cogeneration system, the fuel which would be used to generate the process steam if there were no cogeneration system. This will be the amount of fuel which will be used by the standby boiler when the cogeneration system is shut down for maintenance. This approach leads to the efficiency estimate of 75% for electricity generation in the true cogeneration component of a combined cycle plant..

# Supporting the Development of a Strategic Energy Framework for Canada:

# An Action Research Program

**Background**

Over the past year, energy system participants have been calling for a new federal-provincial "energy framework." However, the composition of such a framework is an open matter. For some, the need is for little more than regulatory streamlining. For others, fundamentally different conceptions of Canada's energy future require debate.

> *"We need a national energy strategy. It must consider our current state, our transition, but most importantly our desired state 50 years from now."*
>
> *Patrick D. Daniel*
> *Enbridge Inc.*

Such a framework must reckon with competing perspectives among provinces, energy suppliers and consumers, and non-government groups. In the Canadian federation, provinces have constitutional authority for development of resources, and energy resource demand and supply differ between regions. Furthermore, trade liberalization and energy sector restructuring are shaping an increasingly integrated North American energy market. A framework for Canada cannot be developed in isolation of continental energy policies and strategies prevailing in both the United States and Mexico.

Two forces are driving the need for Canada to reframe energy policies:

- The quest for North American energy security, and
- The need to develop and use sustainable forms of energy.

Worries about terrorism, instability in the Middle East, and supply constraints in gas, oil and electricity have combined to raise the profile of North American energy security within the past two years. The higher base price and price volatility in natural gas and oil is unlikely to go away for some time, if ever. The instability of regions supplying imported oil (and increasingly, LNG) will not be resolved quickly. The August 2003 Great Lakes blackout - although not primarily a supply problem - nevertheless contributed to concerns about reliable supplies of energy.

Climate change has been high on the list of issues dominating energy policy discussion in Canada since the Kyoto Protocol was developed in 1997. With entry into force of the Kyoto Protocol, climate change, along with other environmental issues such as air quality, will continue to influence and shape policies that will affect North American energy supply and demand. In addition, other environmental concerns including land impacts in fossil fuel producing areas and air quality concerns in areas where the fuel is

processed and used must be factored into the decision making framework. But such environmental goals need to be reconciled with other energy policy objectives such as affordable and reliable energy supplies, Canadian competitiveness and prosperity, technology development, energy export and regional economic development. Some will argue that the increased resources required within governments to focus on climate change over the past seven years have been to the detriment of other energy priorities such as supply constraints, infrastructure needs, security concerns, and regional development.

Sector restructuring and regulatory uncertainty have increased investor risk at a time when Canada's energy infrastructure is aging and needs upgrading and replacement. The power production fleet installed during the great building boom of the post-war era is old and large amounts of capital will be needed to ensure efficient and reliable infrastructure is available to replace the aging plant. Additional infrastructure will be required to meet the growing demand for energy driven by economic and population growth. This will necessitate extensive technology development and deployment plus a regulatory regime that is predictable and conducive to the long timeframes necessary to develop and exploit energy resources. In addition, Canada will need to be seen as a stable energy investment opportunity with reliable regulatory structures and the possibility of attractive returns.

**An Energy Research Program**

Given the challenges that must be addressed, The Conference Board of Canada proposes to launch an Energy Research Program shortly, *to support the development of a strategic energy framework for Canada*. This program will include senior players on the Canadian energy scene who will identify major issues impacting Canada's current energy picture and recommend a program of research to focus these issues and identify possible solutions. The program will seek to inform decision-makers on public policy measures that encourage:

- The use of markets to ensure secure and reliable energy supply at market prices,
- The development of a diverse supply structure,
- An energy approach that addresses both continental trade and environmental issues,
- The development of alternative and renewable energy resources,
- Development of and investment in new and emerging technologies that will enhance energy use and supply,
- Meaningful measures to foster a high rate of energy efficiency among businesses and citizens.

Envisaged as a two year program, it would undertake specific research projects, tackling such key issues as:

1. *Regulatory co-ordination and streamlining*: This has been a constant call from energy system participants and their associations for some time. Co-ordination and streamlining is needed between and within governments so as to reduce governmental and proponent expenditures. **A research project might identify areas of regulatory overlap and lack of co-ordination and then assess innovative approaches to regulatory co-ordination and streamlining**, **with a view to providing meaningful advice to address Canadian applications where most feasible or urgent.**

2. *Improving policy coherence:* Over and above the need for regulatory streamlining, it is important to minimize policy conflicts between and within governments. Of particular concern is the need to dovetail climate change plans with broader energy supply and self-sufficiency goals. **A research project might identify current "policy disconnects" in Canada**, **assess the institutional mechanisms and integrated approaches that can be used to improve policy coherence, and recommend appropriate action.**

3. *Promoting development and deployment of new energy technologies:* The replacement of current energy capital with a reliable, innovative, low-emission stock will be critical to reducing carbon emission intensities and achieving a future with adequate energy. This program will investigate policy measures that encourage both the development in Canada of new energy technologies with export potential, as well as, policies that induce the implementation of proven technologies from other jurisdictions. **A typical research project could evaluate current and past technology development policies at the national and provincial levels and recommend changes based on their effectiveness.**

4. *Smart signals for energy investments*. Canada needs to increase its energy supply from many sources. It will also face increasing costs to acquire new supply, as expensive frontier sources are tapped. And there will be an increasing desire for "clean" energy. What are the "smart" signals – regulations and fiscal incentives - required? **A research project might examine the energy technology and investment policies that have worked well in other OECD jurisdictions, using multi-criteria analysis to recommend the most appropriate policy instruments to match chosen goals in Canada.**

5. *Competing perspectives on energy futures:* It is important not only to ask "What kind of energy future do we want?" but also "What kind of an energy future can we get?" While answers to both questions will vary, responses to the first question will be driven more by the values and interests of stakeholders than responses to the second. **A research project might develop several scenarios of plausible and desirable energy futures, score their desirability by a range of stakeholders, identify obstacles to their realization, and suggest actions where there appears to be consensus.**

**Value of this Program**

By participating in this two-year Program, your organization will:

- *Help shape the formation of sound Canadian public policies affecting energy based on rigorous analysis rather than opinions and perceptions;*
- *Deepen its understanding of the views and priorities of other energy stakeholders; and*
- *Contribute to better-informed Canadian policymakers and policy.*

The Conference Board of Canada is recognized as an independent research organization that can tackle policy issues, such as those proposed in this program, in a neutral and balanced way. It has the capacity to do in-depth research and facilitate dialogue among stakeholders in order to build a mutual understanding of the key issues, the policy options to resolve these challenges, and the economic, environmental and social implications of these options. The Conference Board also has access to top opinion leaders and is very effective in communicating insights on key policy issues to media and policymakers.

Participants will develop with the Conference Board team the research agenda, and propose strategies for disseminating the research findings. They will also have the opportunity to review these findings and draft reports. The group will be invited to meet occasionally and participate in conference calls in order to provide input to the research process - from identifying the research topics and outlines of the chosen projects, to the research findings and draft reports.

**Funding**

Funding participants in this Program will be sought from the range of private sector firms (oil and gas, electricity, coal, renewables, hydro, major power users), and federal and provincial government departments. We anticipate a total funding level of $240,000 per year for two years will be necessary to adequately cover these issues.

Participants are asked to commit for two years at an annual fee of $12,200. We expect a critical number of organizations will co-fund this Program so that adequate revenue will cover the costs of research, networking, and communication. We know that time is precious; we will ask as little of it as possible from participants, and strive to maximize the value of each hour spent on this Program.

**If you wish to join this important Program, please contact either:**

Gilles Rhéaume
Vice-President, Policy Business and Society (rheaume@conferenceboard.ca)
(613) 526-3090 ext. 325

John Roberts,
Director, Environment, Energy and Transportation (robertsj@conferenceboard.ca)
(613) 526-3090 ext. 312

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Shell Trading

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September 1, 2005

Ontario Power Authority
175 Bloor Street East
North Tower, Suite 606
Toronto, Ontario M4W 3R8

Attention: Jan Carr, CEO

**Subject: Recommendations with Respect to the Appropriate Mix of Electricity Supply Sources**

Coral Energy Canada Inc. is a member of the Electricity Market Investors Group (EMIG) and fully supports EMIG's comments and recommendations on "supply mix" that were submitted directly by EMIG. We would like to offer a few additional recommendations on "supply mix" to those recommendations developed by EMIG.

**Renewable Energy**
Targets for new renewable energy capacity should be accompanied by measures to ensure that renewable energy developments are supported in a competitive market. Market measures such as cap and trade mechanisms allow market valuations of emissions, allowing market participants to make "clean" choices on generating technologies and operating strategies at the lowest economic cost for the overall system. These types of measures allow renewable generation technologies to compete with more conventional technologies in a market without subsides or out of market pricing terms, while achieving the ultimate objective of lower emissions and cleaner air.

**Supply Mix**
The following are recommendations with respect to the appropriate mix of electricity supply sources after accounting for conservation and renewable sources.

- The long-term plan should also consider not just new generating developments but Ontario's existing generating capacity to ensure this existing capacity and its owners are receiving returns from the market that are sufficient to maintain the reliability of this capacity.

- Barriers and impediments that restrict the efficient and timely development of "clean" generation technologies should be identified in the plan. Where barriers exist, the OPA should work with the appropriate agencies to remove or reduce these barriers.

In closing, we would like to emphasize the importance of encouraging competitive responses to the Ontario's generation supply challenge. The need for efficient and clean sources of new energy is global, and Ontario should remain open to new, innovative technologies. A long-term plan that establishes a preferred supply mix based on today's available technologies may lead to Ontario to overlook improvements and breakthroughs in other competing technologies such as, coal gasification.

Regards;
**SHELL TRADING**

Greg Baden
VP, Power

To: OPA (Supply Mix Submissions)
Subject: Fw: [B-SAN] Clean Air Alliance - action

The message below says it all for me. I fully support a target of 60% renewable energy by 2020, and phasing out of coal and nuclear energy..
Please keep me informed.
My e-mail address is cpc42@rogers.com

Colin Creasey

----- Original Message -----
From: "Rosemary Keenan" <rosemarykeenan@rogers.com>
To: <bsan-l@list.web.net>
Sent: Thursday, August 04, 2005 4:49 PM
Subject: [B-SAN] Clean Air Alliance - action

> **Brampton Social Action Network - See Activists' Tool Box Below **
> The Minister of Energy has asked the Ontario Power Authority (OPA) to
> develop recommendations for what Ontario's future electricity supply mix
> should be. The Minister will then likely act on these recommendations to
> set targets for long-term planning, including deciding how much the
> province should rely on renewable energy and conservation to meet its
> future power needs.
> Right now, the OPA is seeking public input on what future power scenarios
> (e.g., different mixes of various power sources and conservation measures)
> it should analyze before developing its recommendations.
> We believe it is very important for the OPA to include a strong
> conservation and renewable power scenario in its analysis. Ground-breaking
> research conducted by the Pembina Institute indicates that it is quite
> possible for Ontario to get 60% of its electricity from renewable sources
> by 2020 while eliminating dirty coal and nuclear power.
> Please join us in asking the OPA to include a scenario with a minimum of
> 60% renewable electricity by 2020 and a full phase-out of dirty coal and
> unreliable nuclear power. You can email your comments to
> supplymixsubmissions@powerauthority.on.ca
> <mailto:supplymixsubmissions@powerauthority.on.ca>. (Submissions must be
> received by August 26, 2005).
>
> For a copy of the Ontario Clean Air Alliance's strategy to obtain 60% of
> our electricity supplies from renewable sources by 2020 click here:
> www.cleanairalliance.org/resource/15month.pdf
> <http://www.cleanairalliance.org/resource/15month.pdf>
>
> Email: info@cleanair.web.ca <mailto:info@cleanair.web.ca>
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> Website: www.cleanairalliance.org <http://www.cleanairalliance.org/>
> _____
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August 25, 2005

Mr. Jan Carr
Chief Executive Officer
Ontario Power Authority
Supply Mix Submissions

Dear Mr. Carr:

Please receive this letter and our report "*Smart Generation: Powering Ontario with Renewable Energy*" as our formal contribution to the OPA consultation on the future supply mix for Ontario.

David Suzuki Foundation welcomes the opportunity to consult on these critical issues. We have participated in numerous Federal and Ontario policy discussions and, through our membership in the Green Energy Coalition, we are an active participant in Ontario Energy Board regulatory initiatives.

*Our Smart Generation* report was produced as part of ongoing efforts to provide clear recommendations on the addition of new renewable energy capacity in Ontario up to the year 2025 taking into account the targets set by the government of Ontario for 2007 and 2010.

Table 3: Ontario's Renewable Energy Potential for Electricity and Thermal Applications (page 9), of the report provides a summary of what can be achieved in Ontario if effective policies are implemented on a timely basis. The remainder of the report provides a detailed analysis of key policies and strategies that have been successfully proven by the countries currently leading worldwide in the field of renewable energy.

*Smart Generation* was also conceived as a complimentary follow-up report to the comprehensive report on efficiency and conservation produced in 2004 by the Pembina Institute for Appropriate Development and the Canadian Environmental Law Association titled "*Power for the Future: Towards a Sustainable Electricity System for Ontario*.

In fact, Table 2: Energy Efficiency Potential in Ontario (page 4) of our report was reproduced from *Power for the Future* to provide a summary of what can be achieved in Ontario by 2020 if the province focuses attentively on developing efficiency and conservation.

The research included in the *Power for the Future* study illustrates that implementation of demand side measures in Ontario could reduce electricity use in Ontario by nearly 15,000 MW of peak capacity by 2020. Most importantly their study shows that these impressive savings can be achieved through the use of currently commercially available technologies, and that Ontario energy users would recover 96% of their investment in more efficient technologies through reduced energy costs.

The record of countries such as Germany and Spain on renewable energy, and of jurisdictions such as California on energy efficiency clearly shows that ambitious targets can be accomplished if the right policies are implemented and public support and participation are actively mobilized.

Furthermore, the substantial response to the government's first 300 MW RFP for renewable energy demonstrates the great interest to participate in the Ontario renewable energy market. The implementation of additional policy mechanisms such as advanced renewable tariffs will enable a wide variety of new participants (e.g. cooperatives, farmers, municipalities, ESCOs, developers, members of the public) to become active in this huge and largely untapped new market for renewable generation.

**Additional considerations to evaluate conservation targets and supply options**

The development of the final OPA advice to the Minister of Energy, in terms of conservation targets, additions of renewable energy capacity, and other supply options (e.g. imports of hydro-electricity from other provinces) should be based on dynamic modeling rather than on linear projections into the future.

This approach is essential so the province can evaluate the different effects of a variety of key parameters (e.g. population growth, fuel and equipment costs, technological advancements, coordination of wind facilities with existing large hydro) and of different policy mechanisms over time (e.g. advanced renewable tariffs, public benefit fund).

In addition, by relying on a dynamic modeling approach which will yield a range of different portfolio options and potential targets, it will be possible to develop a better understanding of the strengths and weaknesses of different policy options and about environmental, financial, technical and social risks. The unique work on dynamic modeling by Professor Matthias Ruth of the University of Maryland could be of particular value to inform the efforts of the OPA.

Reliance on dynamic modeling will assist the OPA in the development of an approach that recognizes the considerable uncertainties in long-term resource planning, and will facilitate the development and evaluation of different portfolios of supply sources and conservation options.

More specifically, in relation to evaluations of different portfolios of supply sources and conservation options, we urge the OPA to consider installation and operation/maintenance costs over different time periods and for different technological options and also to consider supply availability constraints and variation in fuel costs associated with different fossil fuels (e.g. coal, natural gas, petroleum) and uranium. The ongoing research by David Hughes, of the Geological Survey of Canada, on energy supply and demand trends provides a readily available starting source for addressing these considerations.

In addition, we strongly advise the OPA to incorporate into all the evaluations of different portfolios of supply sources and conservation options explicit quantification (including monetization), of environmental and social costs (such as emissions of greenhouse gases, air pollutants, radioactive waste, effects on human and ecosystem health and other public risks such as the uninsured catastrophic risks shielded by the federal Nuclear Liability Act).

**Concluding recommendations**

To develop Ontario's full potential of conservation, efficiency and renewable energy and to ensure that the multiple benefits of these options (e.g. environmental protection, job creation, industrial development opportunities) are harnessed to benefit local communities, we provide the following policy recommendations:

1. *Mainstream grid scale renewables so that they are prioritized by the Ontario Power Authority (OPA).*

2. *Include in the supply and efficiency mix strong targets for distributed renewable energy sources such as on-site solar thermal options, geothermal heat pumps, and biomass digesters.*

3. *Enact and negotiate stable, advanced renewable energy tariffs (ARTs) to provide specific electricity generation (kWh) payments for each renewable energy option (taking into account project location, market share, and level of technological development), and to establish and facilitate the right for renewable energy generators (REG) to connect into the electricity grid.*

4. *Implement a stable funding mechanism to finance the activities of the Conservation Bureau and to thereby develop energy efficiency opportunities throughout Ontario to their full potential.*[1]

[1] Some viable options for stable funding include: developing a public benefit fund based on a 0.3 cent surcharge in each kWh sold in the province; levying a carbon tax on electricity generated by fossil fuels (as it is done in the Netherlands). For more information on the funding alternatives currently used in the U.S. see www.cleanenergystates.org/Funds/

5. *Collaborate with the federal government in the establishment of a provincial revolving loan fund to provide interest free loans to install renewable energy distributed generation systems in farms, residences and businesses throughout the province.*

6. *Initiate a process with the federal government to quantify the environmental and social costs of all forms of electricity generation and delivery so these costs can be included into the price of each electricity option to better inform investment comparisons.*

7. *Develop a collaborative process with the largest provincial users of electricity (e.g. auto and steel manufacturers, mining companies) to establish a rational system to deal with electricity peak use.*

8. *To stimulate market transformation, encourage all levels of government (provincial and municipal) to use their procurement capacity to purchase their electricity needs from renewable energy sources, and to ensure that all new government-funded buildings incorporate renewable energy technologies for heating and cooling purposes.*

As our research and that of our colleagues at Pembina Institute and the Canadian Environmental Law Association indicate, Ontario has abundant opportunities to use electricity more efficiently, and has an immense variety of renewable sources to satisfy its current and future power needs. Furthermore, with its industrial infrastructure and skilled workforce, the province has all the elements needed to replace its aging electricity system with a variety of sustainable options.

We would be pleased to meet with you and your staff to discuss in more detail the points contained in our contribution.

Sincerely,

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# Smart Generation

## POWERING ONTARIO WITH RENEWABLE ENERGY

David
Suzuki
Foundation

# Smart Generation

## POWERING ONTARIO WITH RENEWABLE ENERGY

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SOLUTIONS ARE IN OUR NATURE

A summary of this report is available at www.davidsuzuki.org

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# 1 Introduction and Summary

## 1. Introduction

Ontario is at an energy crossroads: the province can either continue to rely on polluting sources to generate electricity and meet the province's demands for heating and cooling, or it can invest in the development of a reliable and sustainable system based on renewable energy and efficiency.

The province's electricity system was originally built on a renewable foundation: hydropower. However, the system is currently dominated by large outdated facilities that burn coal –the most polluting fossil fuel – and by aging nuclear plants, which are characterized by unresolved safety issues (e.g. safe disposal of radioactive waste), chronic underperformance, and massive cost overruns. In addition, the 2003 blackout illustrated the vulnerability of the current electricity system, which depends heavily on large centralized plants overwhelming a fragile electric grid.

Recently, Ontario's Minister of Energy estimated that fixing the province's electricity system will require between $25 to $40 billion dollars.[1]

Crucial decisions related to this investment will be made in the coming months and could perpetuate the problems of the current system or can instead result in positive changes that will permanently improve the reliability and sustainability of the province's electricity system.

This vast investment presents a unique opportunity to decrease electricity demand through efficiency measures, and shift to renewable energy options, substantially improving the electricity system, increasing energy security, and benefiting the environment and the economy. Developing a diversity of local renewable energy sources throughout the province could help reduce power losses and increase the reliability and flexibility of Ontario's electricity system.

Ontario's heating needs are now almost all met with natural gas, and natural gas has been widely promoted as a potential alternative to coal generation.

Although natural gas may be a cleaner fuel than coal, its use still impacts air quality and human health, and its production has significant environmental consequences in the form of wilderness and habitat destruction.[2]

Furthermore, the contribution of natural gas generation to climate change is only slightly less than coal (on an energy basis).

Finally, a decrease in natural gas reserves has meant a doubling of its price – with wild price fluctuations – both of which make it a less attractive and more volatile alternative for electricity generation than efficiency strategies and renewable energy.

There is also an opportunity to meet power generation and heating needs using efficiency measures and renewable energy sources instead of natural gas.

To help inform the ongoing decision-making process, this report summarizes the potential of the most salient renewable options available in Ontario: wind, hydropower, biomass, solar, and ground heat.

The report illustrates how the abundant renewable resources of wind and hydropower can be effectively integrated in Ontario to provide a cost-effective, reliable, and clean alternative to conventional generation.

In addition, the report highlights how myriad renewable energy technologies can be used in rural and urban communities throughout the province to achieve a more diverse and reliable electricity system, and also to light, heat, and cool all types of buildings.

The report also identifies key policy mechanisms that can help Ontario become a North American leader in renewable energy and thereby achieve a more stable and reliable electricity system, a cleaner environment, and the development of a new and vibrant economic engine.

## 2. Ontario's current electricity situation

Large and aging coal and nuclear power plants currently dominate Ontario's electricity system.[3]

**TABLE 1**

Ontario's Electricity Mix[4]

| Source | GWh | % | Peak (MW) | % | Capacity (MW) |
|---|---|---|---|---|---|
| Coal | 35,098 | 23 | 5,865 | 23 | 7,285 |
| Nuclear | 61,040 | 40 | 7,140 | 28 | 10,720 |
| Hydro | 33,572 | 22 | 6,375 | 25 | 7,665 |
| Peaking Gas and Oil | 12,208 | 8 | 3,060 | 12 | 4,645 |
| Imports | 10,682 | 7 | 3,060 | 12 | |
| **Total Demand** | **152,600** | | **25,500** | | **30,315** |

Ontario's generation plants are interconnected to electricity users by a provincially-owned grid that serves an area of 640,000 km$^2$. In most locations, generation plants and electricity users are currently located far away from each other, which leads to a continuous average power loss of eight percent as electricity is delivered (totaling a loss close to 2000 megawatts of peak power).[5]

In addition to transmission losses, energy is routinely wasted during electricity generation as both coal and nuclear plants are inefficient at generating electricity.[6]

Decades of relying on supply by a narrow and limited number of large generators, instead of efficiency strategies and a diverse generation portfolio, has characterized Ontario's electricity system. Furthermore, the poor performance and lackluster safety record of Ontario's nuclear facilities has resulted in the current detrimental dependency on provincial coal generators, and has created the most costly ongoing financial liability in Canada's electricity sector.[7]

This financial liability has three main components: accumulated debt accrued until the dissolution of Ontario Hydro in 1999, additional liabilities accumulated by Ontario Power Generation from 1999–2003, and expected and estimated liabilities related to nuclear plant refurbishments.

The accumulated debt from Ontario Hydro totals approximately $38.1 billion transferred by the provincial government to the Ontario Electricity Financial Corporation upon the restructuring of Ontario's electricity sector on April 1, 1999.[8]

The additional liabilities represent approximately $1 billion (from the return of Pickering A Unit 4 to service and other nuclear operations) accumulated by Ontario Hydro's successor, Ontario Power Generation, between 1999-2003.[9]

The cost of rebuilding Pickering A, Unit 1 to service is currently estimated by the government to total approximately $900 million.[10] It is important to note that when the OPG Review Committee recommended the Unit 1 re-start in March 2004, the estimate quoted to complete the project was $500 million.[11]

Growing concerns about nuclear safety led to a plan to conduct repairs in Ontario's nuclear facilities in 1997.[12] The total refurbishment costs for Ontario nuclear generating facilities have recently been estimated to range between $14.2 to $19.2 billion dollars.[13] These significant costs severely compromise the financial health of Ontario's electricity system and should call into question the viability of any further nuclear power development.

In addition to exacerbating Ontario's debt, the required repairs of nuclear facilities increased provincial dependency on coal plants. As coal burning for electricity generation grew, air pollution levels consistently worsened in Ontario. This ongoing problem has become especially severe in southern Ontario during hot summer days that favour smog creation.

Growing health concerns about air pollution resulted in a promise during the 2003 provincial election by the Ontario Liberal government to phase out coal by 2007. This election promise was followed in 2004 by provincial targets to decrease electricity use by 5 percent through efficiency and conservation by 2007, and by goals to increase the use of renewable energy to 5 percent of total energy capacity by 2007 and 10 percent by 2010.

As this report illustrates, these goals represent modest targets that can be surpassed if clear policies are implemented to diversify, encourage, and support the adoption of renewable energy sources throughout the province.

Further evidence for implementing renewable energy sources in Ontario was provided in June 2004 by the more than 4,400 megawatts (MW) of renewable energy bids

submitted as part of the government's request for proposals to develop 300 MW of renewable energy.[14]

Currently hydroelectric facilities represent the main use of renewable energy in Ontario. However, most of these hydroelectric plants are not representative of the low-impact renewable technologies available today (e.g. wind turbines, small hydro facilities, landfill gas, solar photovoltaic).

Presently new renewable technologies are almost absent in Ontario's electricity generation mix. As an example consider wind turbines, which currently represent about 15 MW of installed capacity in Ontario. In stark contrast Germany, with a surface area about one-third the size of Ontario, had by the end of 2003 14,609 MW of installed wind capacity (and in 2003 alone installed 2645 MW of wind capacity).[15]

Although low-impact renewable energy currently represents only two percent of the global share of energy use, renewable sources such as wind power and solar photovoltaic are growing at impressive exponential rates and faster than any other energy sources in the world.

A further indication of the growing importance of the renewable energy sector is the fact that in 2003 about $26.9 billion –the equivalent of one-sixth of all the global investment in power generation equipment – was spent on renewable energy development.[16]

## 3. Current electricity path threatens Ontario

Ontario's current dependency on coal for electricity generation regularly compromises public health and environmental quality in Ontario.

Severe smog alerts have come to characterize Ontario's summer season, and the burning of coal for electricity generation represents a primary source of local air pollution.[17]

Furthermore, a report released in 2004 by the North American Commission for Environmental Cooperation shows that the province's largest coal plant, Nanticoke, is responsible for eight percent of all of Canada's reported toxic air emissions.[18]

Several recent studies have linked air pollution exposure with negative health consequences, including cardiovascular, respiratory, developmental impairments and lung cancer.[19] For several years the Ontario Medical Association (OMA) has highlighted the acute health effects associated with fine particulate matter and ground-level ozone in Ontario, which cost over $1 billion per year in direct costs for hospital admissions, emergency room visits and absenteeism.[20]

The OMA has noted that these estimates do not reflect the costs associated with medication or visits to doctors' offices. Quantification of these costs entails significant ethical dilemmas; nevertheless, data published by the OMA indicates that the pain, suffering, and loss of life associated with air pollution costs Ontario citizens another $9 billion per year.[21]

In addition to their direct contribution to air pollution, the latest government figures indicate that coal plants also produce about 17 percent of all the greenhouse gas (GHG) emissions of Ontario – an amount comparable to the GHG emissions of all of Ontario's automobiles and light-duty trucks combined.[22]

Scientists worldwide agree that GHG emissions from the burning of fossil fuels, such as coal, oil, and natural gas are the key contributors to climate change.[23]

In recognition of the severity of the challenges posed by climate change, the federal government ratified the Kyoto Protocol in 2002, which commits Canada to reduce its GHG emissions by 6 percent per year (from 1990 levels) by 2012. This commitment entails reducing annual greenhouse gas (GHG) emissions by 240 megatonnes (MT).[24]

Replacing coal generation with a combination of renewable energy and efficiency measures would enable Ontario to reduce air pollution and significantly reduce its share of GHG emissions, and thereby help Canada fulfill its international obligations.[25] Efforts to implement such strategies should be explicitly supported at the national level as part of Canada's Kyoto implementation plan.

Furthermore, the synergistic benefits of such federal and provincial collaboration are highlighted by evidence from European jurisdictions, which suggests that a proportion of the implementation costs of Kyoto policies can be recuperated by reduced costs of air pollution.[26]

A recently signed memorandum of understanding between Ontario and the federal government constitutes a first step towards developing and implementing a new set of collaborative policy measures to ensure that renewable energy sources and efficiency strategies are developed to their fullest potential.

The public health and environmental costs of burning coal (e.g. air pollution, emission of GHGs), and of relying on nuclear power are significant (e.g. safely disposing of

radioactive waste), but are not yet accounted in any way in the pricing of electricity.

In addition, the price of electricity generated from burning coal is also artificially lowered through the favourable federal income tax treatment of coal mining.[27]

In the case of nuclear power, a viable solution for nuclear waste disposal still remains as an unanswered and costly question. Consider that the Auditor General of Canada noted almost ten years ago that a long-term solution for high-level radioactive waste was estimated by Atomic Energy of Canada Limited to cost $9 billion (in 1991 dollars).[28]

Additionally, instead of reflecting its environmental and social costs, the price of nuclear energy has been artificially lowered for decades through at least $6 billion of direct federal government subsidies that have existed since 1946 (in the 1987–1999 period, federal spending on nuclear technology totaled about $2 billion).[29]

The fact that significant costs are largely ignored but are still paid through public funds (e.g. provincial health care budgets) greatly distorts the real price of coal and nuclear electricity.

If all the environmental and social costs and existing government subsidies for coal and nuclear power were taken into account, renewable energy sources would not require any special support to compete.[30]

However, since efforts to reflect these costs and subsidies in electricity prices have not been conducted and are not yet planned, policy measures are required to level the playing field.

## 4. Clean alternatives for meeting Ontario's power needs

Several recent studies have analyzed the huge potential for reducing electricity use in Ontario through efficiency and conservation.[31]

These studies highlight two important facts for policy-makers: the bulk of all investments in energy efficiency can be paid through the expected energy savings; and just as with renewable energy development, energy efficiency investments can result in important local economic benefits (such as employment creation).[32]

It must be recognized that only a few measures, such as peak reductions achieved through demand response measures by large electricity users, can be implemented as single concerted efforts.[33] Almost all the other strategies to achieve the efficiency gains summarized in Table 2 will require an integrated set of policies and initiatives covering a broad spectrum of activities and products.

Clear evidence already exists in North America showing what can be accomplished in Ontario through

**TABLE 2**

Energy Efficiency Potential in Ontario[34]

| | 2010 | | | 2015 | | | 2020 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GWh | Peak (MW) | Capacity (MW) | GWh | Peak (MW) | Capacity (MW) | GWh | Peak (MW) | Capacity (MW) |
| IMO Forecast | 164,000 | 27,800 | | 172,000 | 28,742 | | 180,000 | 30,079 | |
| Demand Reductions-Efficiency/ Cogeneration | (26,867) | (4,510) | | (53,002) | (8,898) | | (73,499) | (12,339) | |
| Additional Load Shifting | | (2,329) | | | (1,984) | | | (1,774) | |
| On-Site Solar Roofs Program | (876) | (250) | 330 | (1752) | (500) | 670 | (2,628) | (750) | 1,000 |
| Grid Demand | 136,257 | 20,711 | | 117,246 | 17,360 | | 103,873 | 15,216 | |
| Existing Nuclear | 51,246 | 5,994 | 9,000 | 22,776 | 2,664 | 4,000 | | | |
| Existing Hydro | 33,572 | 6,375 | 7,665 | 33,572 | 6,375 | 7,665 | 33,572 | 6,375 | 7,665 |
| Existing Peaking Gas and Replaced Oil | 12,208 | 3,060 | 4,645 | 12,208 | 3,060 | 4,645 | 12,208 | 3,060 | 4,645 |
| Wind | 7,884 | 1,317 | 3,000 | 13,140 | 2,196 | 5,000 | 18,396 | 3,074 | 7,000 |
| New Hydro | 4,380 | 600 | 1,000 | 6,570 | 900 | 1,500 | 8,760 | 1,200 | 2,000 |
| Biomass | 3,504 | 234 | 500 | 4,205 | 281 | 600 | 5,606 | 375 | 800 |
| New CCNG Base Load | 23,915 | 3,570 | 4,200 | 25,054 | 3,740 | 4,400 | 25,623 | 3,825 | 4,500 |
| Total Supply | 136,709 | 21,150 | 30,010 | 117,525 | 19,216 | 27,810 | 104,165 | 17,909 | 26,610 |
| **Contingency** | **452** | **440** | | **278** | **1,856** | | **292** | **2,693** | |

efficiency strategies. A noteworthy example is the state of California, which has already reduced peak power demand by 20% or 10,000 MW over the past 20 years by relying on efficiency standards (for buildings and appliances) and utility demand side management programs.[35]

In early 2004, the Pembina Institute released a study that showed that electricity consumption and peak demand could be reduced to 30% below 2004 levels by 2020 through a series of energy efficiency and demand reduction policies. These policies would include equipment efficiency standards and codes, demand-side management incentives to utilities, a small public benefits charge to finance energy efficiency, and efforts to fast track efficiency improvements. The study also showed that the cost to Ontario consumers to achieve these goals would be less than adding new supply facilities, and that no new technologies would be required – just the most efficient that are commercially available today.

The Pembina study also looked at how the remaining demand for electricity might be met through a combination of renewable energy and natural gas – eliminating both coal and nuclear energy sources by 2020. This work confirmed similar research carried out by Torrie Smith in 2003.[36]

Both the Pembina Institute and Torrie Smith studies used available data on renewable resource potential.

This report was commissioned to obtain a better assessment of Ontario's renewable electricity potential and also estimate the thermal contribution that these resources could provide.

## 5. The pitfalls of natural gas

Natural gas has been widely promoted as a potential alternative to coal generation, and as the primary source of heat for buildings and industrial processes.

Although natural gas may be a cleaner fuel than coal, its use still impacts air quality and human health, and its production has significant environmental consequences in the form of wilderness and habitat destruction.[37]

Furthermore, the contribution of natural gas generation to climate change is only slightly less than coal (on an energy basis).

Finally, a decrease in natural gas reserves has meant a doubling of its price – with wild price fluctuations – both of which make it a less attractive and more volatile alternative for electricity generation than efficiency strategies and renewable energy.

Contrary to its clean image, natural gas contributes to climate change. Although burning natural gas produces fewer greenhouse gas emissions than coal or oil (25–40% lower, per unit of generated electricity), natural gas still creates emissions when it is produced, processed, and transported.[38]

Further, there are two significant unresolved issues related to the economic costs of increasing reliance on electricity generation from natural gas: price increases and price fluctuations.

Many energy experts are predicting that natural gas prices have established a new equilibrium at $3.50-$4.00 per thousand cubic feet (Mcf), compared to the $2/Mcf mark around which North American gas prices fluctuated over most of the 1980s and 1990s.[39] The reason is that continued growth in gas-fired electricity in North America – driven by U.S. demand – is not matched by proven reserves of natural gas.[40]

Canada is the largest source of natural gas for the U.S., but Canada's reserves are dwindling. Based on proven reserves and 2002 production figures, Canada has only nine years of production unless new reserves are discovered.[41] In the long run, increased supply will not be able to match demand. Already, Canada's natural gas production is expected to decline by 3% between 2002 and 2005 because "many of the new fields coming on-stream are small and quickly depleted."[42] This reality will keep natural gas prices high in North America, and may potentially increase them further.

In the past, Canadian natural gas consumers – including electricity providers – have been economically buffered from U.S. demand as limited pipeline capacity has meant that natural gas consumers north of the border have not had to compete with the massive U.S. appetite for natural gas. However, this buffer is quickly disappearing. The Alliance Pipeline (B.C. to Illinois), the Maritimes & Northeast Pipeline (Nova Scotia to Massachusetts), and others have meant that more of Canada's natural gas production now gets burned in the U.S. than in Canada. Ironically, increased capacity pushes up the price Canadians pay for Canadian natural gas.[43]

The second price concern relates to the fluctuation in natural gas prices. Like all commodities, natural gas undergoes constant changes in its price. This is especially of concern for electricity utilities with significant amounts of gas-fired power.

Natural gas prices and electricity prices influence each other. When natural gas prices go up, the cost and price

of electricity goes up, and vice versa.[44] Gas-fired power generators have options to decrease the risk of gas price volatility, but these instruments come at a premium.[45] In other words, volatility can be contained, but only by pushing up the price of natural gas even further.

Finally, the option of using natural gas as a "transition fuel" also poses risks. That is because the pipelines required to transport natural gas from its source to power plants are expensive. High pipeline costs have to be spread out by building several gas-fired power plants that last a generation or more.[46]

Instead of committing to such problematic transition, Ontario can emulate the development path of world leaders such as Germany, Spain, and Japan and actively develop the best available renewable technologies.

## 6. Benefits of renewable energy in Ontario

Ontario enjoys a unique comparative advantage due to its abundant and diverse renewable energy sources, which can be used to provide a clean and reliable supply of electricity.

In addition to electricity generation, a variety of renewable energy sources are highly viable to provide heating and cooling (space conditioning) for Ontario's residential, commercial and institutional buildings. Solar, biomass, and geothermal technologies are better alternatives to the massive use of electricity and fossil fuels (e.g. natural gas, oil and propane) currently employed in space conditioning applications.

Renewable technologies represent safe energy choices, which help protect human health and ecosystems, provide economic and energy security, are easy to put in place and create more jobs than fossil-based generation and nuclear plants.

Wind and solar PV facilities can be built in modular steps (e.g. extra turbines can be added or removed to match electricity demand), do not have fuel costs, and can be implemented faster that any other generation option currently available. Wind plants can be built in just one year, which enables developers to respond more accurately to electricity use projections and short-term changes in demand.[47]

Renewable energy technologies can also be installed as smaller power units along the grid and also directly where electricity is used (a concept known as 'distributed generation'), an approach that allows reducing the capital costs and losses of transmission and distribution inherent to centrally generated power.[48] These costs combined can total up to half of delivered power costs.[49] Distributed generation leads to a more stable and secure electricity than the current system based on centralized utilities.

Renewable energy sources represent the biggest source of job creation amongst all power generation options as documented by a comprehensive study released in 2004 by researchers from the University of California.[50]

Because of their greater potential for creating employment, renewable energy policies represent a key tool for community economic development. For example, it is estimated that wind energy projects can support rural communities by providing tax revenues and jobs for rural municipalities and new sources of lease income for rural landowners ($2,500–$5,000 a year per turbine).[51]

Ontario enjoys the additional benefits of possessing a skilled labour force and an advanced industrial base that, with the right policies, can become a solid foundation to develop the abundant renewable energy resources available throughout the province. This report examines five sources of renewable energy: wind, hydroelectricity, biomass, solar and geothermal.

### WIND

Wind is the fastest growing source of energy in the world, but Ontario is lagging behind. There is great potential for large-scale wind power generation in the province. The technically achievable wind resource in Southern Ontario is 86 terawatts-hour (TWh) annually, or about 58% of current provincial consumption.

Based on European experience, especially that of Germany and Spain, Ontario could install as much as 8,000 MW of wind-generating capacity by 2012. A fleet of wind turbines representing an installed capacity of 8,000 MW could generate 14 TWh annually, or about 10% of current consumption.

Using the same assumptions as a recent economic impact study of Quebec's 1,000 MW tender for wind-generating capacity, 8,000 MW of wind capacity installed in Ontario could produce nearly $14 billion in economic activity and 97,000 person-years of employment.[52]

### HYDROELECTRICITY

Although wind power is an intermittent resource, management techniques can be enacted so that during times of low wind availability, Ontario's proposed 8,000 MW of wind turbines could be backed up by a

portion of the existing provincial hydroelectric facilities that have water reservoir capacity. Coupling wind power with hydroelectricity is a key strategy to ensure the province has a significant and stable source of renewable electricity when needed.

Furthermore, if coordination measures are implemented to ensure that hydroelectric facilities collaborate with wind power producers, renewable energy can then be used effectively to manage electricity peaks. This innovative integration strategy is currently used in the state of Oregon and provides a viable and practical solution to manage the intermittent nature of renewable resources such as wind.[53]

The province also has an additional 1,000 MW available from small, low-impact hydropower development and potential hydroelectric refurbishments, capable of generating about 5.7 TWh per year.

### BIOMASS

Ontario can develop 2,450 MW of power generation using a variety of biomass sources, which can generate 14.7 TWh per year, provide a new source of income for the province's forestry and agricultural sectors, and help deal effectively with their residues. In addition to electricity generation, biomass sources can generate 114 petajoules (PJ) of green heat that can be used to displace electricity and fossil fuels currently used for residential and commercial space heating.

### SOLAR

Surveys of the world's solar photovoltaic (PV) market consistently show that growth rates of 30% or more have become an established trend. These high growth rates are leading to a general continuing downward trend in grid-connected PV system prices. Markets for solar water and space heating are also increasing at impressive rates of about 26% per year.

If supportive policies for solar energy are implemented in Ontario the province could install 1,263 MW of PV systems; 800,000 solar domestic hot water systems; 120,000 solar pool heaters; solar passive design in 420,000 new homes; 2,000 000 $m^2$ of commercial and institutional solar hot water systems; and 825,000 $m^2$ solar air ventilation systems. The combined energy output of these solar systems has the technically feasible potential of supplying by 2025 the equivalent power that coal provided in 1999, or about half the electricity generated by all of Ontario's nuclear power plants.

### GEOTHERMAL

Geothermal heat pumps (GHP) are the most cost-effective option to provide space conditioning (heating and cooling) in Ontario. GHP can be widely used to provide heating and cooling for all new residential and commercial buildings in the province. Ontario could install by 2010, 125,000 residential GHP systems that would provide space conditioning needs (heating and cooling) and save the equivalent of 2,148,400 MWh per year (7.7 PJ). By 2020, the province can install 341,000 residential GHP systems that would provide space conditioning and save the equivalent of 5,777,200 MWh a year (20.8 PJ).

A basic premise of this report is that energy efficiency and conservation strategies are the most logical complement to the widespread use of renewable energy sources. Aggressive energy efficiency measures are essential to ensure that Ontario becomes proficient at obtaining more energy services from lower electricity supply.

## 7. Renewable energy mechanisms (REM)

The current policy initiatives intended to support renewable energy at the provincial and federal level (e.g. provincial renewable portfolio standard and net metering; existing federal incentives such as the wind power producer incentive and the renewable energy deployment initiative) are not adequate to achieve the high rates of adoption of renewable energy that are possible and necessary in Ontario. A detailed analysis regarding the shortcomings of these existing policy mechanisms is provided in subsequent chapters, in relation to each specific renewable energy technology.

Countries such as Germany, Spain, and Japan are leading the world in the adoption of renewable energy and provide clear examples of what can be quickly achieved if the right policy mechanisms are in place.

Their leadership and success is based on a set of common factors: very active political commitment for renewable energy; supportive education initiatives for R&D and public awareness; strong incentive systems to achieve widespread public participation; and implementation of an effective policy path based on the use of renewable energy mechanisms (REMs).

The concept of REMs is simple: they allow the connection of renewables to the grid and they specify the price paid for renewable generation in the form of

fixed-price contracts. Through an inclusive public policy debate, legislative assemblies determine the premium to be paid for every kilowatt-hour generated from different renewable technologies.

As such, these premiums represent informed, politically negotiated decisions as opposed to politically determined quotas that limit the amount of renewables to be implemented.

Germany, without particularly favourable wind or solar resources, has become the world leader in wind installations and is only second to Japan in solar photovoltaic. Germany currently has over 14,600 MW of installed wind capacity, and in 2003 alone installed 2,645 MW of wind turbines (by comparison the U.K., which has one of the best wind regimes around, has only a total of about 649 MW of wind turbines).[54]

## KEY SOURCE OF REM: GERMANY'S RENEWABLE ENERGY FEED-IN LAW

Germany has become a world leader in renewable energy by implementing a sophisticated renewable energy law (referred here as REM) that has eliminated two of the most important obstacles inhibiting renewable energy development: the ability to connect to the grid, and market uncertainty. The law provides firm prices for an extended period of time to warrant the financial risk of investment – and to ensure market adoption of a variety of renewable options.

One of the first forms of REM originated in 1991, when Germany's conservative government introduced a law requiring utilities across the country to pay 90% of their annual average retail rate for purchases from clean energy sources such as wind turbines. The law, encompassing only a few paragraphs, resulted in an explosion of wind-generated electricity and has positioned Germany as a world leader in renewable energy applications.

In July 2004, the German parliament replaced previous versions of its 'feed-in law' with a new Renewables Act. The act is intended to increase the total contribution of renewable energy to Germany's electricity supply, from 5% to at least 12.5% by 2010 and at least 20% by the year 2020. This is equivalent to renewable portfolio standard (RPS) targets of 12.5% and 20%. However, the mechanism designed to reach targets uses a more sophisticated approach than that in the original feed-in law or that of the renewable portfolio standards (RPS) currently used in Canada and the United States.

Rather than setting the premium as a percentage of retail rates, the specific premium for each technology was chosen after parliamentary debate informed by technical reports from the German Wind Energy Institute and the Institute for Solar Energy Research. As an example of the practical outcomes of this debate, consider that German parliamentarians chose higher premiums for less windy sites to encourage development in low wind areas of central Germany. Their intent was to disperse wind turbines across the landscape, rather than concentrating huge installations only in the windiest locales. This strategy reduces location problems and potential land-use conflicts, and better integrates the turbines into the electricity network.

By carefully targeting the premiums to be paid for wind and other renewables, Germany's REM law aims to diversify the use of a variety of renewable energy technologies, and achieve sustained market transformations.

The renewable premiums are revisited twice a year to monitor how the program is meeting Germany's objectives, and premiums are then adjusted accordingly. New premiums were adopted in the spring of 2004.[55]

The revised feed law also spells out, for the first time, how to calculate the costs for grid connection and for any necessary reinforcement of the distribution system. The new law then equitably apportions these costs to both parties: the system owners and the grid operator. The law also increases the transparency of how these costs are determined, by allowing system owners to use third-party consultants and contractors with access to all pertinent technical information to advise them whether the fees are fair.[56]

No other renewable energy support mechanism in the world has produced more renewable energy than the German REM.

## SPAIN'S REM

Spain offers two programs: a fixed premium for projects less than 50 MW, or a bonus payment on top of the wholesale price. Nearly all of Spain's wind projects have been built using the fixed-premium mechanism. Spain, a nation of 40 million inhabitants, now closely rivals the United States in total installed wind capacity. Since 1999 Spain has installed nearly 1,000 MW of new capacity annually, often much more, and by the end of 2003 had over 6,200 MW of installed wind capacity. Spain's REM,

and its policy – not unlike the provincial policy of Quebec – of encouraging domestic manufacturing, has created a dynamic market with two indigenous manufacturers, Gamesa Eolica and Ecotecnia, as well as a host of Spanish affiliates of Northern European manufacturers. Spanish manufacturer Gamesa Eolica's strong position in the competitive Spanish market has enabled it to begin exporting to the United States.

## DANISH REM

The Danish parliament created the Danish REM system to encourage individual action toward meeting their energy and environmental policy. For two decades, Danish energy policy enabled farmers, businesses, and homeowners to install wind turbines, which they owned outright, or in which they owned a share. Danish law permitted inter-connection of wind turbines with the grid and specified the premium that would be paid for their production.

The Danish REM system provided a stable domestic market for Danish wind turbine manufacturers. The program was so successful that Danish manufacturers are now leaders in the technology and Danish wind turbines are exported around the world. Today, Denmark produces nearly 20% of its electricity with wind energy.

The REM program was scrapped in the early 2000s in favor of a certificate trading system. The poor results from the trading system recently led to the abandonment of the program and the country may re-install an REM system.

## OTHER COUNTRIES WITH REM

In total there are nine countries in Europe and South America using renewable energy mechanisms as the principal mechanism to support renewables (Austria, Brazil, France, Germany, Greece, Luxembourg, Portugal, Spain, and the Netherlands). Countries that have recently adopted REMs include Austria and the Netherlands. Like Denmark, the Netherlands had switched from REM to a certificate trading system in the early 2000s, but they then reintroduced REM in 2004. Two more European countries are considering REMs: Italy for solar-electric systems, and the Czech Republic for wind and solar energy.

REMs are more egalitarian than almost any other support mechanism, enabling communities, cooperatives, and farmers as well as commercial renewable energy developers to participate in the rapid expansion of renewable capacity.

The fixed-premium contracts under REM reduce price volatility from utility purchases in the spot market, helping to ensure price stability.

REMs can also be an integral part of a conservation culture by instilling in consumers and the market the necessity of paying for value. Renewable energy has a higher value because of its environmental, social, and technical benefits and therefore its price should reflect this.

**TABLE 3**

Ontario's renewable energy potential for electricity and thermal applications

| | Installed capacity | Electricity generation (GWh/Year) | Thermal contribution PJ/Year |
|---|---|---|---|
| **Wind** | 8,000 MW (2012) | 14,000 | |
| **Hydroelectric (low-impact)** | 1,000 MW (2020) | 5,700 | |
| **Biomass:** | | | |
| Electricity | 2,450 MW (2010–2020) | 14,700 | |
| Thermal | | | 114 |
| **Geothermal heat pumps** | 125,000 systems (2010) | | 7.7 |
| | 341,000 systems (2020) | | 20.8 |
| **Solar:** | | | |
| Photovoltaic (PV) electricity | 1263 MW (2025) | 1,263 | |
| Thermal | 800,000 SDHW (2025) | | 9.6 |
| | 120,000 SPH (2025) | | 6.6 |
| | 420,000 new homes with SPD (2025) | | 85.7 |
| | 2,000 000 $m^2$ of C & I SHW (2025) | | 4.0 |
| | 825,000 $m^2$ SAV (2025) | | 7.2 |

Note.
SDHW = solar domestic hot water systems
SPH = solar pool heaters
SPD = solar passive design
C & I SHW = commercial and institutional solar hot water
SAV = solar air ventilation.

## 8. Conclusion and recommendations

The current government approach to deploy renewable energy in Ontario entails the high risk that only the most profitable sites (e.g. areas with the highest wind speeds) will be developed, and that only a few renewable energy technologies will be used (e.g. large wind and hydro-electric facilities, landfill gas).

Clear policies are required to ensure that all the renewable energy sources that exist throughout the province are fully tapped in a sustained and stable manner. Furthermore, smart policies are also needed to develop favourable conditions so a wide variety of participants and local organizations can actively engage in the implementation of large-scale and distributed generation systems in rural and urban areas.

The accumulated experience from the six countries leading in the worldwide adoption of renewable energy is clear: success is achieved through conscious policy decisions that create increasing demand for renewable energy technologies, ensure favourable access to the electricity grid at fair prices, facilitate low cost financing, provide tax incentives and smart subsidies, legislate standards, support education initiatives, and encourage active stakeholder participation.[57]

All the estimates about resource and technical potential of various renewable energy technologies are estimates based on the best available information from peer-reviewed journals, government and industry data from Ontario and other jurisdictions. While these figures are well-informed general estimates, they are not a substitute for more comprehensive analysis of the provincial renewable energy potential, and its associated economic and health benefits. The federal and provincial government should collaborate to conduct such analysis as soon as possible.

To develop Ontario's full potential of renewable energy and to ensure that the multiple benefits of renewable energy (e.g. job creation, industrial development opportunities) favours local communities, this report provides the following policy recommendations:

1. **Expand the mandate of the proposed Conservation Bureau (hereafter referred as Sustainable Energy Bureau) to include development of distributed renewable energy sources such as on-site solar, geothermal heat pumps, and biomass digesters.**
2. **Position the proposed Sustainable Energy Bureau centrally in the machinery of the OPA so that conservation, efficiency and renewable energy – the very essence of a robust electricity system – are the priorities that shape the entire agenda of the OPA. Whether this Sustainable Energy Bureau has its own board or an advisory body, it must have the authority and practical tools to influence the operation of the entire electricity system.**
3. **Mainstream grid scale renewables so that they are prioritized by the Ontario Power Authority (OPA).**
4. **Enact and negotiate stable, renewable energy mechanisms (REM) to provide specific electricity generation (kWh) payments for each renewable energy option (taking into account project location, market share, and level of technological development), and to establish and facilitate the right for renewable energy generators (REG) to connect into the electricity grid.**
5. **Implement a stable funding mechanism to finance the activities of the Sustainable Energy Bureau.[58]**
6. **Consolidate federal support to implement a provincial education strategy to train and certify renewable energy specialists and installers, quantify and map all renewable resources available in the province, increase public awareness on renewable energy potential and support programs.**
7. **Collaborate with the federal government in the establishment of a provincial revolving loan fund to provide interest-free loans to install distributed generation systems in farms, residences and businesses throughout the province.**
8. **Initiate a process with the federal government to quantify the environmental and social costs of all forms of electricity generation and delivery so these costs can be included into the price of each electricity option to better inform investment comparisons.**
9. **Develop a collaborative process with the largest provincial users of electricity (e.g. auto and steel manufacturers, mining companies) to establish a rational system to deal with electricity peak use.**
10. **To stimulate market transformation, direct all levels of government (provincial and municipal) to use their procurement capacity to purchase**

**their electricity needs from renewable energy sources, and to ensure that any new government-funded building incorporates renewable energy technologies for heating and cooling purposes. This strategy should be financed through new federal-provincial collaborations and should start by working with large government users of electricity such as the Toronto Transit Commission to purchase all their electricity from renewable energy sources (as is already done through Calgary Transit's initiative "Ride the Wind").**

As this study illustrates, Ontario has abundant opportunities to use electricity more efficiently, and an immense variety of renewable sources to satisfy its current and future power needs. Furthermore, with its industrial infrastructure and skilled workforce, the province has all the elements needed to replace its aging electricity system with a variety of sustainable options.

The next chapters of this report illustrate the vast opportunities for implementing efficiency and renewable energy strategies available in Ontario and present additional policy mechanisms to tap into these significant opportunities.

### INDUSTRY JUMPS ON CONSERVATION BANDWAGON

Falconbridge, a large Toronto-based mining company, has a network of energy managers identifying how the company can save consumption costs year round.

Falconbridge's corporate goal is to reduce energy intensity by one percent per year by 2005 based on 1990 levels.

During the summer, Falconbridge shuts down its Sudbury and Trimmings smelters for maintenance and vacation – a plan that has been in place for several years.

The shutdown is timed in an effort to avoid the high-energy demand and high-cost electricity periods of the summer months. In this way, the company is better able to meet its energy cost budgets and reduces the potential impact of brownouts and blackouts should the provincial electricity system become overloaded.

During the summer, crews continue to take ore out of the ground but stockpile it so that Falconbridge's metallurgical plants can operate at full capacity for the remainder of the year.

To further control energy use, Falconbridge's Sudbury Mines/Mills Energy Management Team created a tool that displays daily energy consumption in its various forms. These "daily consumption reports" help lower energy use. For example, jobs that are not time-sensitive, such as the hoisting of materials, can be shifted to hours with lower electricity rates. The reports also help identify waste, such as underground equipment running when not needed, and the use of excess compressed air.

## INTRODUCTION NOTES

1 In speech delivered at the Empire Club, Minister Duncan stated that Ontario faces an energy crisis and that "it needs to refurbish, rebuild, replace or conserve 25,000 MW of generating capacity by the year 2020 to meet growing demand while replacing polluting coal fired generation. That represents 80 percent of Ontario's current generating capacity and would require an investment of $25 to $40 billion". For more details see Ministry of Energy press release (April 15, 2004): "New Vision For Electricity Sector Will Mean New Supply, Increased Conservation, Stable Prices" available at www.energy.gov.on.ca/index.cfm?fuseaction=english.news

2 It is a fact that natural gas-fired power plants emit lower levels of sulphur dioxide and nitrogen oxides than coal-fired plants. However, these lower emissions remain a concern, since they contribute to acid rain and ground level ozone, both of which can damage forests and agricultural crops. Ground level ozone (commonly called smog) has also been linked to a range of respiratory illnesses. More recently, ground level ozone has been linked to the development of childhood asthma, the "most common chronic disease" among children. See National Institute of Environmental Health Sciences. (2002). Multi-Sports in Ozone May Raise Asthma Risk. Press Release (January 31, 2002 available at www.niehs.nih.gov). Possibly more troubling are the emissions of fine particulates from gas-fired power plants. Though particulate emissions are about one-tenth what they are for coal power, the U.S. Environmental Protection Agency estimates that 77% of particulates from natural gas plant are of a dangerously small size.

3 The government of Ontario intends to retire the following coal plants by 2007 (year of installation): Lambton (1969), Nanticoke (1972), Lakeview (1962), Thunder Bay (1963 & 1982), Atikokan (1985). Ontario's nuclear plants will all have to be retired by 2018 (year of installation): Pickering A (1971–1973), Pickering B (1983–1986), Bruce A (1976), Bruce B (1984), Darlington (1992–1993).

4 Reproduced from Table 1.1 page 3 of: Winfield, M.S., Horne, M., McClenaghan, T. and Peters, R. (2004). *Power for the Future: Towards a Sustainable Electricity System for Ontario*. Calgary: Pembina Institute for Appropriate Development and Canadian Environmental Law Association, available at www.pembina.org

5 This amounts to approximately 2,000 MW of capacity; the equivalent of the entire Pickering A nuclear generating station or enough energy to power 1,000,000 Ontario homes.

6 The average efficiency of generating infrastructure ranges between 30–40 percent. That is, only 30–40 percent of the potential energy in the original fuel source (coal, gas, etc.) is actually converted to electricity (the other 60–70 percent is lost as waste heat); see NRCan. (2004). *Energy Efficiency Trends in Canada*. Ottawa: NRCan. Available at http://oee.nrcan.gc.ca/neud/dpa/data_e/Trends04/chapter_8.cfm

7 These liabilities include construction cost overruns as well as cost overruns for repairs. For example, the Darlington nuclear plant rose from an original estimate of $3.95 billion in 1978 to a final actual cost of $14.4 billion. For more details see Appendix 2 of Winfield, M.S., Horne, M., McClenaghan, T. and Peters, R. (2004). *Power for the Future: Towards a Sustainable Electricity System for Ontario*. Calgary: Pembina Institute for Appropriate Development and Canadian Environmental Law Association, available at www.pembina.org. The repairs of Pickering Unit 4 were estimated in 1999 to cost $457 million and were expected to be completed by mid 2001, the actual costs totaled $1.25 billion and were completed by September 2003; for more details see Epp, J, Barnes, P. and Jeffrey, R. (2003). *Report of the Pickering "A" Review Panel*. Available at www.energy.gov.on.ca/english/pdf/pickering_report_dec2003_en.pdf

8 Ontario Electricity Financial Corporation. (2003). 2003 Annual Report Ontario Electricity Financial Corporation. Toronto: OEFC. Available at http://www.oefc.on.ca/pdf/oefc_ar_2003_e.pdf

9 OPG income before income taxes for 1999–2003 was (amounts in millions of dollars and amounts in brackets indicate liability): Pickering A unit 4 return to service ($1571), other nuclear operations ($1,571), fossil and hydro operations ($50), electricity markets $1,672, other factors $442; for more details see Ontario Power Generation financial reports available at www.opg.com/ir/reports.asp

10 See Ministry of Energy press release (July 7, 2004): "Ontario Government Restarts Pickering Unit To Increase Electricity Supply" available at www.energy.gov.on.ca

11 See page 49 of Manley, J., Epp, J., Godsoe, P. (2004). *Transforming Ontario's Power Generation Company: Report from the Committee to Review Ontario Power Generation*. Available at www.energy.gov.on.ca/index.cfm?fuseaction=electricity.reports_opgreview

12 According to Winfield et al. (op. cit. note 4, pp.2 and 48) a 1997 Ontario Hydro report titled: "Report to Management IIPA/SSFI Evaluation Findings and Recommendations" prompted Ontario Hydro to adopt its Nuclear Asset Optimization Plan (NAOP), which led to the repairs of four units at Pickering A and three units at Bruce B.

13 See page 30 of Winfield et al. (2004) op.cit. note 4.

14 See Ministry of Energy (June 24, 2004) press release: "McGuinty Government Sparks Interest In Green Electricity " available at www.energy.gov.on.ca. On April 28, the government initiated a Request for Proposals (RFP) for 300 megawatts of renewable electricity to identify interested proponents. For more details see www.ontarioelectricityrfp.ca

15 Ontario's wind figures reproduced from Canadian Wind

Energy Association (www.canwea.ca/en/CanadianWindFarms.html), and German figures reproduced from European Wind Energy Association (www.ewea.org).

16 Sawin, J.L. (2004). Mainstreaming Renewable Energy in the 21st Century. Washington D.C.: Worldwatch Institute. Available at www.worldwatch.org

17 For more details see page 20 of Ontario Clean Air Alliance. (2004). *Phasing Out Coal: Six Month Progress Report*. Toronto: OCAA. Available at www.cleanairalliance.org

18 Commission for Environmental Cooperation. (2004). *Taking Stock 2001: North American Pollutant Releases and Transfers*. Montreal: CEC. Available at www.cec.org/files/PDF/POLLUTANTS/TS2001-Report_en.pdf

19 For a summary of key epidemiological studies see page 110 of Somers, C.M., McCarry, B.E., Malek, F, and Quinn, J.S. (2004). Reduction of Particulate Air Pollution Lowers the Risk of Heritable Mutations in Mice. *Science*, 304 (May 14), 1008–1010.

20 Ontario Medical Association (2001). Ontario's Air: Years of Stagnation. Toronto: OMA. Available at www.oma.org

21 Ibid see page 6.

22 According to Ontario Power Generation, in 2001 Ontario's five coal plants emitted 35.1 megatonnes (Mt) of $CO_2$. See page 52 of Ontario Power Generation, *Towards Sustainable Development: 2001 Progress Report*, available at www.opg.com/envComm/SED2001Report.pdf. According to the latest published government figures, Ontario's total 2001 greenhouse gas emissions where 201 Mt $C0_{2eq}$ (in 2001 all the automobiles and light-duty trucks used in Ontario emitted close to 35.5 Mt). For details see p.186 of Olsen, K. et al. (2003). *Canada's Greenhouse Gas Inventory 1990–2001*. Ottawa: Greenhouse Gas Division, Environment Canada. Available at: www.ec.gc.ca/pdb/ghg

23 See IPCC. (2001). *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J.T.,Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge: Cambridge University Press. Available at www.ipcc.ch

24 Government of Canada. (2003). *Climate Change Plan for Canada*. Available at www.climatechange.gc.ca./plan_for_canada/

25 For details see Stewart, K. (2003). Ontario and Kyoto. Ottawa: Climate Action Network. Available at www.climateactionnetwork.ca/resources.html

26 For example see: European Environment Agency. (2004). *Exploring the Ancillary Benefits of the Kyoto Protocol for Air Pollution in Europe*. Copenhagen: EEA. Available at: http://reports.eea.eu.int/technical_report_2004_93/en

27 For details see sections 3.69, 3.71 and Appendix C in Commissioner of the Environment and Sustainable Development. (2000). *Government Support for Energy Investment*. Ottawa: Office of the Auditor General. Available at: www.oag-bvg.gc.ca/domino/reports.nsf/html/c003ce.html

28 "Atomic Energy of Canada Limited estimated, based on the results of this program, that the cost of finding a site and constructing, operating and closing a HLW disposal facility for five million bundles of used fuel is about $9 billion (in 1991 dollars). This estimate includes ongoing research and development on potential sites but excludes costs of monitoring the environment around the facility." See chapter 3, Federal Radioactive Waste Management, in Office of the Auditor General. (1995). 1995 Report of the Auditor General of Canada. Ottawa: Office of the Auditor General. Available at: www.oag-bvg.gc.ca/domino/reports.nsf/html/9503ce.html#0.2.NJDBJ2.9FBMWI.A4RLQE.W4

29 See Commissioner of the Environment and Sustainable Development. (2000). Op.cit. endnote 24 exhibits 3.33 and exhibit 3.4.

30 One of the few reports to incorporate environmental costs to the price of power in Ontario was conducted in 1997 and resulted in a generation price for coal power of 10 cents per kWh and for nuclear power of 15 cents per kWh. See Argue, D. (1997). *A Review of the Economic Cost of Power in Ontario*. Available at www.newenergy.org/costofpower_report.html. Note that these figures are within the range of a recent evaluation, conducted by Sawin op.cit note 13, which incorporated environmental and health costs into the cost of electricity generation using European and U.S. data. Sawin's calculations resulted in a generation price for coal power of 9–29 cents per kWh and for nuclear power 13–19 cents per kWh (Sawin's original figures where converted from U.S. currency using a conversion rate of $1 U.S. = $0.76 CAD)

31 See for example Winfield op.cit. note 4 and Torrie, R. and Parfett, R. (2003). Phasing Out Nuclear Power in Canada: Toward Sustainable Energy Futures. Ottawa: Campaign for Nuclear Phaseout. Available at www.cnp.ca

32 Winfield et al. (2004, p.37, op. cit note 4) state that capital investments of $18.2 billion over the 2005–2020 period would be required to achieve the efficiency gains described by their research and that 96% of these costs would be recovered by consumers through the energy savings resulting from that investment.

33 For example, peak reductions achieved through demand response measures by large electricity users. Estimates developed for the IMO indicate that up to 10% of Ontario's peak demand could be shifted through demand response measures (DRM). About 2 percent of the province's customers (e.g. mining firms, steel and car manufactures) use about 50 percent of Ontario's power so DRM can be organized between the government and this group of large power users to improve provincial power use and to achieve industrial production gains. See Winfield, op.cit. note 4 and Bloom, R. (2004).

Corporations keep their cool on power: As temperatures rise, big consumers plan no changes to production, Globe and Mail (June 29, 2004).

34 Reproduced from table 5.10 Winfield et al. (2004) op.cit note 4.

35 Bachrach, D., M. Ardema, and A. Leupp. *Energy Efficiency Leadership in California: Preventing the Next Crisis.* (San Francisco: Natural Resources Defense Council, 2002). The full report is available at: www.nrdc.org/air/energy/eecal/eecal.pdf

36 See Winfield et al. (2004) op. cit. note 5 and Torrie and Parfett (2003) op.cit. note 31.

37 See note 2.

38 Lechtenbohmer, S., Fischedick, M., Dienst, C. and Hanke, T. (2003). GHG-Emissions of the Natural Gas Life Cycle Compared to other Fossil Fuels (in Europe). *Proceedings from the 3rd International Methane and Nitrous Oxide Mitigation Conference, Nov. 17–21*. Beijing, China: Wuppertal Institute.

39 See, for example Energy Information Administration. 2003. "Annual Energy Outlook 2003." Electronic database accessed on April 1, 2004 at http://www.eia.doe.gov/bookshelf/brochures/aeo2003/AEOBrochure.html.

40 The U.S. added 67,000MW of gas-fired power between 1980 and 1999, and an additional 111,000MW of power is projected by 2007 in the western North America grid alone. Foley, D., Herzog, S. and Scott, G. (2001). *British Columbia at the Crossroads: Clean Energy or More Pollution?* Vancouver: David Suzuki Foundation.

41 Energy Information Administration. 2004. "Country Analysis Briefs: Canada." Electronic database accessed on April 14, 2004 at www.eia.doe.gov/emeu/cabs/canada.html

42 Ibid.

43 See page 13 of Wilson, F. (2001). *Who's making money on natural gas prices? What should government do?* Vancouver: Canadian Centre for Policy Alternatives.

44 In 2000, several events brought about an eleven-fold increase in the price of wholesale electricity, which drove up natural gas prices to record levels. True, an ill-conceived deregulation plan in California was a key reason for the increase. But with more and more jurisdictions taking the deregulation route, electricity prices – and, by extension, natural gas prices – may continue to fluctuate for Canadian utilities relying increasingly on gas-fired power. In fact, price volatility has continued, even well after the California debacle. For more details see p.4 of Bolinger, M., Wiser, R. and Golove, W. (2004). *Accounting for Fuel Price Risk When Comparing Renewable to Gas-Fired Generation: The Role of Forward Natural Gas Prices*. Berkeley: Lawrence Berkeley National Laboratory.

45 Ibid. p. 6–8.

46 For example, building a natural gas pipeline to Vancouver Island would require three new large gas-fired plants, doubling BC Hydro's greenhouse gas emissions. For more details see Jaccard, M. (2002). Gas pipeline a project deserving real public debate. *Vancouver Sun,* January 3.

47 One-year construction estimate based on page 6 of Canadian Wind Energy Association. (2004). *Submission by the Canadian Wind Energy Association to the Federal/Provincial/Territorial Council of Energy Ministers' Meeting July 19, 2004/Iqualuit, Nunavut*. Available at www.canwea.org Combined cycle natural gas plants can be built in about two years (for example see Ford, A. (2001). Simulation Scenarios for the Western Electricity Market: Paper for the California Energy Commission Workshop on Alternative Market Structures for California. Available at: www.wsu.edu/~forda/bbust.html).

48 Further benefits of this approach include: modularity, short lead time, fuel diversity and reduced price volatility, load-growth insurance and load matching, reliability and resilience, local and community choice and control, avoided emissions and environmental impacts. See Dunn, S. (2002). Micropower: New variable in the Energy-Environment-Security Equation, *Bulletin of Science, Technology and Society*, 22 (2), 72–86.

49 Beck, F. and Martinot, E. (in print). *Renewable Energy Policies and Barriers*. Available at www.martinot.info/re_publications.htm

50 Kammen, D.M., Kapadia, K, and M. Fripp (2004) *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* RAEL Report, University of California, Berkeley. Available at http://ist-socrates.berkeley.edu/~rael/renewables.jobs.pdf

51 Canadian Wind Energy Association op.cit note 47.

52 Hélimax. (2004). *Étude sur L'Évaluation du Potentiel Éolien, de son Prix de Revient et des Retombees Économiques Pouvent en Déouler au Québec, Dossier R-3526-2004.* Montreal: Hélimax. Available at http://www.helimax.com/dossier_r35262004.pdf. For 1,000 MW: 6.7 person-years/$1 million; 121.5 person-years/TWh for operation. For 4,000 MW: 7.7 person-years/$1 million; 107.9 person-years/TWh. Note: it is not explained in the text why there would be more people employed per dollar invested at 4,000 MW than 1,000. Assuming 4,000 MW installed at the rate of 1,000 MW/yr and operating for 25 years, the German employment values would produce about 97,000 person-years, versus the Helimax's estimate of 78,000 person-years.

53 The Bonneville Power Authority currently offers two systems to support wind power using hydroelectricity: a network wind integration service and a storage and shaping service; for details see www.bpa.gov/Power/PGC/Wind/wind.html

54 See graphic 2 press release of European Wind Energy Association (March 10, 2004): "Record euro $8 Billion of wind power installed globally in 2003" available at www.ewea.org/04media/press.asp

55 REMs in the new EEG cover wind, solar photovoltaic in several different applications, hydro plants of various sizes, several forms of biomass, and geothermal plants of

various sizes. For the actual mechanisms see http://www.ontario-sea.org/REMs/GermanREMs2004.xls

56 For an explanation of how the German mechanisms came into effect and how they are applied see Wilson Rickerson, German Renewable Energy Feed In Tariffs Policy Overview, http://www.ontario-sea.org/REMs/REMsRickerson.html

57 For the past decade six countries: Denmark, Germany, India, Japan, Spain and the United States have achieved 80 percent of the world's wind and solar installation through policy mechanisms that address these factors (Sawin, op.cit. note 16).

58 Some viable options for stable funding include: developing a public benefit fund based on a 0.3 cent surcharge in each kWh sold in the province; levying a carbon tax on electricity generated by fossil fuels (as it is done in the Netherlands). For more information on the funding alternatives currently used in the U.S. see www.cleanenergystates.org/Funds/

# 2 Wind Power in Ontario

## Summary

**Worldwide experience shows that** by investing in and developing wind power, Ontario will help create a more stable and reliable electricity system, a cleaner environment and new economic opportunities.

There is no comprehensive wind resource assessment of Ontario. New digital maps are being prepared, but they were not ready in time for this study. However, using accepted estimating techniques and the performance of wind turbines operating in similar wind regimes in Germany, a significant wind resource has been identified. The technically achievable wind resource in Southern Ontario is 86 TWh annually, or about 58% of current provincial consumption.

Based on European experience, especially that of Germany and Spain, Ontario could install as much as 8,000 MW of wind-generating capacity by 2012. This is more ambitious than the tender by Quebec for 1,000 MW of wind capacity, but it is in line with the pace of current European development. This fleet of wind could generate 14 TWh annually, or about 10% of current consumption.

Using the same assumptions as a recent economic impact study of Quebec's 1,000 MW tender for wind-generating capacity, 8,000 MW of wind capacity installed in Ontario could produce nearly $14 billion in economic activity and 97,000 person-years of employment.

Despite a modest wind resource, Germany is the world's wind energy powerhouse. Wind turbines in Germany are capable of generating more than 28 TWh per year, the equivalent of nearly one-fifth of Ontario's current electricity consumption. Germany has a dynamic and competitive market for wind energy because of its renewable energy mechanisms. These mechanisms eliminated two of the most important obstacles inhibiting wind development: the ability to connect to the grid, and a firm premium for an extended period of time to warrant the financial risk of investment.

German renewable mechanisms pay one price for wind turbines in windy areas, and higher prices for turbines located at less windy sites. This is intended to avoid the concentration of wind turbines in only the windiest locales and ensure that wind turbines are distributed across the country.

Currently there are no renewable mechanisms in Ontario and the province has launched a tendering system instead of renewable mechanisms. Analysis of existing experience shows that tendering systems have not succeeded in creating dynamic markets.

## 1. Background on wind energy[1]

Wind energy is one of the most successful of the new renewable technologies developed during the latter part of the 20th century. From humble beginnings as the darling of backyard tinkerers and anti-nuclear activists in Denmark in the late 1970s, Danish technology leapt the Atlantic and fueled the great California "wind rush" of the early 1980s.[2] Though not without its technological and commercial setbacks, the wind industry has continued to grow and prosper over the intervening two decades.

### 1.1 Worldwide wind development[3]

At the end of 2003 there were 40,000 megawatts (MW) of commercial wind-generating capacity operating worldwide, some three-quarters of that in continental Europe.[4]

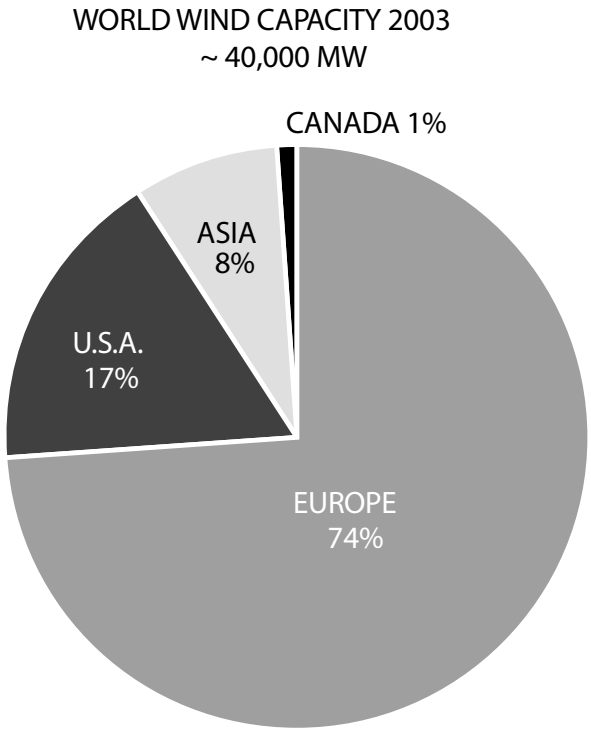



FIGURE 1 World wind capacity. Wind energy is growing rapidly worldwide with most of the growth taking place in Europe. About three-quarters of the world's wind generating capacity has been installed in the densely populated countries of continental Europe, notably Germany, Spain, and Denmark. Despite its size, wealth, and early start in wind energy, the U.S. accounts for less than one-fifth of the world's wind capacity.

By contrast, North America with a much greater land mass and a lower population density than Europe, accounts for less than one-fifth of total world wind capacity. Nearly 8,000 MW of new wind capacity was installed in 2003 alone.

Nearly 300 MW were installed offshore in 2002 (equivalent to almost all of Canada's installed capacity). Most of that was in Denmark, but there were some 20 MW installed off the Dutch and the Swedish coasts. Altogether, offshore installations accounted for 3% of the world market in 2002. By 2007 offshore wind is expected to account for 14% of the world's new wind capacity.[5]

The technological and commercial development of offshore wind projects in Danish, British, Irish and German territorial waters may have a profound effect on wind development in Ontario. With the province's 1,500 km of shoreline along the Great Lakes and the shallow waters offshore, there is significant potential for development in this area. Typically, offshore projects are more expensive to develop than sites on land. However, the greater unobstructed winds available offshore and the reduced turbulence over water combine to produce greater yields than found on land nearby. In addition, the province already owns all rights for development offshore which can greatly facilitate offshore wind installation.

## 1.2 WIND ENERGY IS A MATURE BUSINESS

Wind energy has become a multi-billion dollar industry. In 2003, total revenues from the sale of wind-generated electricity, wind turbines, towers, and development services reached nearly $28 billion.

The Canadian Wind Energy Association (CANWEA) estimates that installing 1 MW of wind power in Ontario currently costs $1.5 million.[6] The largest project installed to date is the 9 MW array of five turbines at the Bruce nuclear plant; however, no data is publicly available on the actual cost of the project. The German wind energy association reports average installed costs across the German wind sector of $1.9 million per installed MW of wind power.[7]

The cost of installed wind generation has dropped remarkably during the past two decades partly by economies-of-scale as the turbines have become larger, and partly by learning how to build, install, and operate wind turbines more effectively.

In the 1990s, the cost for of turbines fell by nearly 20% for every doubling of the number of wind turbines manufactured.[8] During the late 1990s, the production of commercial-scale wind turbines doubled almost every three years.

## 1.3 TECHNICAL CONSIDERATIONS

### 1.3.1 INTEGRATION

Some utilities have been reluctant to consider wind energy as a significant new source of generation because of concerns about the quality of the power produced, the difficulty of regulating wind's variable generation, and confusion about the true value to the utility of wind generation. Some utilities worry that wind energy, because it is intermittent, is "unreliable" and is not able to provide firm capacity.

On the surface, it appears that a resource that cannot be controlled at will threatens the reliability of an integrated electric utility. Fortunately, a better understanding of wind technology is overcoming the concern about wind energy's intermittency – what to do when the wind stops blowing. Although wind power technology has surpassed institutional knowledge, the idea lingers.

That is, according to conventional wisdom, utilities would still need the same amount of generating capacity with or without wind power plants, because the wind is intermittent, or it is sometimes unavailable when most needed.

### 1.3.2 CAPACITY CREDIT

Although wind turbines may be idle due to a lack of wind at times of a utility's peak demand, there is a statistical probability that they will be available, especially if there are multiple wind turbines dispersed geographically across a region. In this, wind turbines are no different from conventional power plants. No generating plant operates 100% of the time, and no power plant is 100% dependable during peak loads.

The work of engineers on both sides of the Atlantic has refuted the notion that wind energy cannot supply some degree of dependable power.[9] The question becomes not if there is any capacity value in wind energy, but what is its value in offsetting the construction of conventional capacity.

Utilities traditionally have viewed wind energy solely as a fuel saver.[10] Each kilowatt-hour generated by a wind turbine offsets a kilowatt-hour that would have been otherwise generated. But in some cases, the capacity value of wind energy to a utility is equal to that of the fuel it offsets.[11]

Moreover, in some locales there is a good fit between the wind resource and the load. One study for Pacific Gas & Electric Company found an exceptional match between the wind resource in California's Solano county and demand justified a capacity credit nearing that of a conventional fossil plant based on a loss of load analysis. Using the same analysis, the utility found a lesser, but not insignificant, value for the Altamont Pass. The capacity credit for the Altamont Pass was found to be surprisingly similar to the area-wide capacity factor.[12]

In a recent report the California Energy Commission examined the capacity value of several sources, including wind energy. The report concluded that the capacity credit for wind energy is significantly lower than conventional resources, "but shows that wind can help reduce system risk. . .the wind capacity credit values are consistent with what we would find for a conventional unit with a very high forced outage rate of about 75%."[13]

European studies have found that up to 20% of demand could be supplied by wind energy without changes to the existing transmission and regulation system.[14]

### 1.3.3 PENETRATION

There are several regions of northern Europe where existing wind generation exceeds 20% of supply annually. Wind supplies nearly 20% of Danish electricity and during windy winter months the contribution is even higher. In some coastal states of Germany, wind's contribution exceeds 20% and in the county of Ostfriesland, wind accounts for more than half of annual supply. In some areas of Europe, wind turbines are net exporters of electricity.

### 1.3.4 SEASONAL MATCH WITH LOAD

There is good seasonal and diurnal match between wind and load in Ontario. Peak seasonal winds occur in winter during the heating season, and in mid afternoons during the summer cooling season. Winter winds are further complemented by the substantial increase in air density of colder air.[15] Seasonal wind resources are predictable enough to make seasonal commitments for displacement of fossil fuels. That is, system planners can, with some degree of reliability, plan seasonal dispatching that includes wind energy.

### 1.3.5 COMPATIBILITY WITH HYDROELECTRIC STORAGE

Wind turbines installed in a modest wind regime such as Ontario will be operating above the cut-in wind speed (i.e. the speed at which wind turbines first start generating electricity), and producing some amount of electricity for more than 6,000 hours per year. At Ontario's more energetic sites, wind turbines will be in operation more than 7,000 hours per year.[16]

Wind, like hydropower, is subject to the vagaries of climate. However, seldom is there a poor wind and a poor hydro year simultaneously. Wind energy is seen as complementary to hydro-electricity systems with some storage. During periods of peak wind and low demand, wind offsets hydroelectric generation and water can be stored behind the dam for release during periods of higher demand.[17]

Wind energy is a local resource, not subject to supply interruptions or depletion. Further, wind energy offers stable long-term prices because there are no fuel costs. Ontario has a long tradition of using hydroelectric generation and planners intuitively understand the benefits of local control of an indigenous resource.

Chapter three elaborates in detail how to take advantage of this potential.

## 1.4 BENEFITS OF WIND ENERGY

The benefits of using wind for electricity generation are numerous.[18] Wind energy creates new jobs, offsets emissions from fossil-fired power plants, offsets external costs, provides net positive energy balance, stimulates new economic development, notably in rural areas, enhances security of electricity supply, and provides electricity price security. Analysis of all of these benefits is beyond the scope of this chapter and therefore we concentrate here solely on job creation and economic development.[19]

### 1.4.1 EMPLOYMENT

Ontario is the industrial center of Canada and has the infrastructure and the skilled workforce needed for manufacturing wind turbines, towers, and their electrical components. Towers are a feasible near-term product for Ontario domestic manufacturing. Towers can account for one-fifth of the installed cost and constitute a good fit with Ontario's steel industry. However, if adequate policy mechanisms are not implemented, provincial employment from developing Ontario's wind resource will be affected by competition within the North American market.

Quebec has announced an interest in a 1,000 MW tendering program to develop wind energy in the province. While not as aggressive as the development program suggested here (8,000 MW in Ontario by 2012), Quebec is wooing manufacturers to locate in the province.

To visualize the employment potential consider that Germany has currently over 45,000 people working in its wind industry (37,000 direct and indirect manufacturing jobs in the German wind industry and another 8,000 additional jobs servicing wind turbines).

Taking the German employment experience, and the accelerated development of wind energy in Europe, it is possible to forecast the potential effects on job creation in Ontario. Assuming that installed costs will likely be lower in Canada than in Germany, the employment effect per megawatt of capacity will potentially be lower than in Europe as well.

Nevertheless, it is possible to estimate the number of people that would be directly and indirectly employed in the manufacturing sector by a build-out that begins modestly at 300 MW in the first year, reaches 1,000 MW per year within five years, and peaks at 2,500 MW in the eighth year. If Ontario's wind development evolves like Germany's and Spain's, there could be nearly 100,000 person-years of cumulative employment by 2012. For comparison purposes this figure can be converted into total jobs per MW by averaging this type of employment over the life of the wind facilities.[20]

A recent study of the economic impact of developing wind energy in Quebec used estimates of the jobs created by manufacturing and installing wind turbines quite similar to those used here. The Quebec study examined job creation over the 25-year life of a wind project and

**TABLE 1**

Potential Employment Creation from Ontario's Wind Development (person-years)

(Derived from Experience in Germany)

| | MW Installed | MW Cumulative | $CAD Installed Cost | $CAD Operations Cost | Manufacturing Jobs (4) | Service Jobs (5) | Total |
|---|---|---|---|---|---|---|---|
| Phase 1 (1) | | | | | | | |
| 2005 | 300 | 300 | 450,000,000 | 16,200,000 | 3,150 | 162 | 3,312 |
| 2006 | 500 | 800 | 750,000,000 | 43,200,000 | 5,250 | 432 | 5,682 |
| 2007 | 500 | 1300 | 750,000,000 | 70,200,000 | 5,250 | 702 | 5,952 |
| 2008 | 700 | 2000 | 1,050,000,000 | 108,000,000 | 7,350 | 1,080 | 8,430 |
| Phase 2 (2) | | | | | | | |
| 2009 | 1000 | 3000 | 1,500,000,000 | 162,000,000 | 10,500 | 1,620 | 12,120 |
| 2010 | 1000 | 4000 | 1,500,000,000 | 216,000,000 | 10,500 | 2,160 | 12,660 |
| Phase 3 (3) | | | | | | | |
| 2011 | 1500 | 5500 | 2,250,000,000 | 297,000,000 | 15,750 | 2,970 | 18,720 |
| 2012 | 2500 | 8000 | 3,750,000,000 | 432,000,000 | 26,250 | 4,320 | 30,570 |
| | | | | **Person-years** | **84,000** | **13,446** | **97,446** |

NOTES
(1). 2,000 MW installed within 4 years.
(2). 4,000 MW total installed capacity within 6 years.
(3). 8,000 MW total installed capacity within 8 years.
(4). 7 jobs/$ million CAD, $1,500 CAD/kW
(5). 10 jobs/$ million CAD, $54 CAD/kW

thus encompasses a much longer time frame than used in our analysis.[21]

Comparing our projections with those of the Quebec study for 4,000 MW over 25 years, our estimates are somewhat higher, but not overly so considering the range of uncertainties.[22]

### 1.4.2 ECONOMIC DEVELOPMENT

**Direct and indirect economic benefits:** Helimax's study examined the economic results from a commercial wind development program and estimated the value added for manufacturing, installation, and operation of 1,000 MW of wind capacity for 25 years. The study estimated that there were $590 million in direct benefits to the Quebec economy if a major portion of the wind turbines and their components were sourced in Quebec. There were an additional $800 million in indirect benefits and the program created another $280 million in economic activity for a total of $1.7 billion in economic benefits over the life of the project.[23]

Using the Helimax assumptions, installing 8,000 MW in Ontario in a phased program by 2012 could generate nearly $14 billion in economic activity in the province. Helimax's most important caveat was the assumption that 50% to 60% of the value added in building the 1,000 MW was sourced in Quebec.

If both Quebec and Ontario aggressively develop wind energy, they will compete for wind turbine manufacturers and their suppliers (towers, for example) to locate in their respective province. The majority of manufacturing jobs will most likely go to the province that the industry believes has the most serious and long-lasting commitment to installing a significant amount of capacity. Ontario is a new and potentially very large market that can lure manufacturers to the province. It is not yet too late to act.

Quebec appears to be seeking one manufacturer for a limited potential market of 1,000 MW over a period of several years. The manufacturer selected will expect to also sell into other provinces and into the U.S. market to make up for the quota-driven Quebec market. By using a quota and tendering system, Quebec sends a signal that it is not seeking a dynamic market of suppliers, but a captive manufacturer who will provide a certain number of jobs in a depressed region.

Ontario can choose to create a dynamic market served by several manufacturers located in the province if there are no limits on the capacity installed annually, that is, by not setting quotas through the Request for Proposal or tendering process. By creating a market that has the potential to exceed 300 MW, 500 MW, or even 1,000 MW per year, Ontario can lure European manufacturers to the province where they can compete to win greater shares of an expanding market. Such a competitive market provides more jobs more quickly than through tendering to one or two captive suppliers.

**Co-location:** Wind turbines can co-locate with most existing land uses. Thus, wind turbines offer landowners, whether rural or urban, commercial or industrial, an opportunity to produce a new cash stream on their property. The wind turbine installed at Exhibition Place by the Toronto Renewable Co-op and Toronto Hydro was the first in North America to demonstrate that wind energy can be located within urban areas. There are many such examples in Europe, including Copenhagen, the capital of Denmark.[24]

Far more significant, however, is the opportunity to use wind turbines in rural Ontario where they can co-exist with crops or pasture.

**Rural economic development:** Wind turbines have provided a new cash crop for farmers in Denmark and in Germany and states such as Iowa and Minnesota. They can do the same for farmers in Ontario.

Wind energy can benefit farmers in two ways. Farmers can lease their land to a wind developer, or farmers can install, own, and operate the wind turbines themselves. Under existing Ontario policy, farmers and small landowners in general are discouraged from supplying electricity to the province.[25]

**Leasing:** Royalties on land leased to commercial wind developers offer farmers the lowest risk means for benefiting from wind energy. The developer bears almost all of the business risk.[26] Farmers can continue doing what they do best – farming. They leave wind development to the wind developers.

Wind leases offer farmers less rewards than if farmers owned the wind turbine directly. Royalties on land leases range from 2% on gross revenues to as high as 5% during the first ten years, up to 6% during the second ten years, and as high as 8% during the third decade.[27] Royalties can accrue on all gross revenues and not solely on the sale of electricity. Some projects sell their green benefits for almost as much as they sell their kilowatt-hours of electricity. Developers may also offer signing options of up to $1,000 and installation bonuses of $2,500 /MW.

Depending upon the price per kWh and the amount generated, a leaseholder could receive $2,500 to $13,000 per MW per year. During the twenty-year life of a wind turbine, farmers with a 1-MW turbine on their land could earn from $50,000 to $250,000 per MW of installed capacity.[28]

A 1-MW turbine would require an area clear of other wind turbines of about 28 hectares. That is, if there were more than one wind turbine, each would occupy an area of open space that permits unhindered access to the wind. However, each turbine uses only 1% to 5% of the land occupied for roads, substations, and ancillary structures.

**Owning:** When farmers or landowners own a turbine they bear all risk themselves, including technical risk, wind risk, and political risk.[29] However, all profit then accrues to the farmers or landowners.

If farmers own their own 1-MW turbine and they received $0.075 to $0.1 per kWh generated, they could earn $100,000 to $225,000 per year in net revenues in Ontario. Once the debt is retired, from ten to fifteen years, the farmer could expect to earn $500,000 to more than $2 million during the twenty-year life of the turbine.

While not risk-free, wind turbines have the potential to more than double farm income for those farmers capable of taking advantage of the opportunity. And all wealth generated by farmer-owned, or locally-owned wind turbines flows from Ontario electricity consumers directly to provincial communities.

Consider a hypothetical case where one-half of Ontario farmers installed one 1-MW wind turbine. The 27,000 MW installed could generate about one-third of Ontario's current consumption. Using the assumptions above, these wind turbines could pump from $3.5 to $4.5 billion through Ontario's rural economy.

Some 30% of Ontario farms have sufficient land area for two 1-MW turbines. Another one-third of Ontario farms have enough surface area for four 1-M turbines. There are 1,000 farms in Ontario with a working area of approximately 400 hectares. Each farm of this size could, in theory, absorb ten 1-MW turbines for 10,000 MW of capacity. The benefits from wind energy for rural Ontario are potentially quite significant.

## 2. Ontario's wind resource: waiting to be discovered

At the time of writing there were no detailed maps of Ontario's wind resource. However, modern digital maps using existing wind data and computer simulation are being prepared, and the Canadian unified mesoscale wind energy atlas prepared by Environment Canada will be released in the fall of 2004.

Early mapping of regional wind resources was based on informed extrapolation of airport data typically measured below 10 metres (m) up to 50, 80 or 100 m above the ground. Much of the wind data available in North America, prior to wind development, was from airport meteorological stations. Data from these stations is often suspect, because the measurements are made on short masts, and are typically unrepre-sentative of what wind turbines would encounter at 50 to 100 m above ground level.

Modern wind turbines use extremely tall towers. The 1.8 MW wind turbines operating in Ontario are at a hub height of nearly 80 m. Towers more than 100 m tall are not uncommon in Europe. Tall towers elevate wind turbines well above the effects of trees, buildings, and other obstructions that retard the flow at meteorological stations on short masts. The tall towers experience a much better wind resource than airport meteorological stations, and often do much better than projected using standard methods of estimating increases in wind speed with height above the ground.

Another source of wind data are meteorological stations. However, the reliability of this data is compromised by the fact that many Canadian meteorological stations are specifically located for agricultural measurements, particularly precipitation, and therefore they are deliberately located in areas where precipitation measurements are not disturbed by winds.

Detailed wind resource assessments conducted over a period of years are imperative to identify areas with the best wind resources.[30]

Contrary to classic economic geography, wind energy development is only indirectly related to the wind resource. Much of the world's wind development has taken place in regions of only modest wind resources. The location, pace, and amount of wind energy development is more directly a function of government policy and incentive mechanisms, than wind resource. This assertion is best illustrated by the contrast between Germany and Great Britain. Germany, by international standards, has a modest wind resource. Britain, on the other hand, has one of the world's best. Yet in 2003 there were more than 14,000 MW of wind-generating capacity operating in Germany and only 650 MW in Britain.

While the early expansion of wind energy in the windy mountain passes of California and along the windswept coastline of Denmark may seem to contradict the previous statement, because they followed traditional development patterns, this is not the case upon close examination. During the early 1980s, a period of rapid expansion of wind energy in California and Denmark, both locations provided a supportive political environment – and most importantly – mechanisms that guaranteed a favourable fixed premium for the wind-generated electricity. With the fixed premium, and in the case of California, with substantial tax subsidies in hand, developers could easily obtain the capital needed to develop large wind projects, leading to the California "wind rush" that lasted from 1981 through 1985.

Denmark followed a different development pattern than California. In Denmark wind turbines were installed singly or in small clusters rather than in large wind power plants. Like California's developers, Danish farmers and cooperatives were able to find financing for their purchase of wind turbines because of the guaranteed premium and the ability to offset environmental taxes on fossil-fired generation.

## 2.1 ESTIMATING ONTARIO'S WIND RESOURCES

### TOTAL RESOURCE

Even by North American standards, Ontario has a huge surface area of about one million km$^2$. Assuming a modest average wind resource of 5 m/s, there is 14,000 TWh of wind energy coursing across the province every year (Ontario currently uses about 150 TWh of electricity annually).[31]

## 2.2 TECHNICAL RESOURCES

The theoretical maximum amount of wind energy that can be extracted from the wind, is 8,000 TWh. In actual operation, most wind turbines deliver far less for a host of reasons, including the interference of one wind turbine with another in a geometric array. Assuming a very open spacing between turbines of eight diameters across the wind by ten diameters downwind (8 RD x 10 RD), there is technically 5,000 TWh available per year across the entire province.

## 2.3 PRACTICAL RESOURCE

Ontario's population and electrical load are concentrated in the southern portion of the province. Partly as a result, the transmission system is also concentrated in southern Ontario. The Canadian Wind Energy Association estimates that there are 300,000 km$^2$ within reach of the existing transmission system, roughly corresponding to southern Ontario.[32] For comparison, southern Ontario is about the same size as Germany, yet with about one-sixth the population density.

**TABLE 2**

Wind resource potential in Ontario

| | TWh/yr | % of 2001 Demand[6] |
|---|---|---|
| Total Resource[1] | 14,000 | 9524% |
| Technical Resource Betz Limit | 8,000 | 5442% |
| Technical Resource[2] | 5,000 | 3401% |
| Practical Resource[3] | 1,500 | 1020% |
| Accessible Resource[4] | 90 | 61% |
| Acceptable Resource[5] | 45 | 31% |

1. 5 m/s @ hub height, 100 m2 land area/m2 rotor swept area, province wide.
2. 00 kWh/m2/year annual specific yield.
3. Southern Ontario only @ 500 kWh/m2/year annual specific yield.
4. One 1-MW turbine per farm; 55,000 farms in Ontario; 600 kWh/m2/year annual specific yield; 2,800 m2.
5. 1/2 the Accessible Resource.
6. 147 TWh/yr in 2001 total Ontario consumption.

Limiting the practical wind resource to southern Ontario only, and using the same assumptions on spacing and wind resource as that for the entire province, there is the potential for 1,500 TWh or 10 times the province's 2001 electricity consumption.

## 2.4 ACCESSIBLE RESOURCE

Without digital data for roads, buildings, parks, wildlife sanctuaries, airports, military bases, First Nations, and other areas where wind development may be prohibited, it is difficult to estimate how much accessible wind resource exists in southern Ontario. However, it is possible to use farmland as a representative surrogate for culturally and politically accessible land areas where wind energy may be permitted.

Farmland represents a working landscape where farmers and the public accept the use of structures and

FIGURE 2 Renewable energy mechanisms (REMs) are essential to enable farmers to benefit directly from wind developments.

mechanical devices on the land. Farmers and the public also expect that farmland will be "tilled" in some manner that requires breaking the soil, growing crops, and harvesting. Farmland is thus not a static landscape. There are seasonal cycles of activity, which reach a peak in spring and fall. Wind turbines are already a common rural feature in many European nations such as Germany, Denmark, and the Netherlands.

Ontario's Ministry of Agriculture and Food lists 85,000 farm operators in the province; however, the Ontario Federation of Agriculture estimates there are only 55,000 individual farms. By definition, these farms are all accessible by road and farm equipment. They may not be accessible to transmission lines of sufficient capacity, but they are all likely served by a distribution line of some capacity.

For illustrative purposes, if every farm installed one 1-megawatt wind turbine with a rotor 60 metres in diameter, and there was a slightly more robust wind resource than that province wide, farming the wind in this manner could generate 90 TWh per year, or nearly two-thirds of the province's consumption.

## 2.5 ACCEPTABLE RESOURCE

Farmers once relied upon wind turbines for irrigation and are again making wind turbines a commonplace feature of the agricultural landscape. One need only travel to Denmark to see how distributed wind turbines have become an integral part of the rural Danish landscape.

It is safe to assume that many of Ontario's farms are not suited for wind development, and that some farmers may not want wind turbines on their property. Furthermore, land use policies may preclude large areas of farmland from consideration.

Again, for illustrative purposes only, assuming that one-half of Ontario's farms could install one 1-MW turbine, or about 27,500 MW, there is still the potential to deliver 45 TWh per year or about one-third of Ontario's total consumption.

Of note is a comparison of this crude technique with data results from a 1991 study of Ontario's wind potential. Examining actual wind data for meteorological stations in southern Ontario, the study tallied the amount of developable land area in each of several wind classes after excluding a portion in each for potential land use conflicts. The study concluded that there was sufficient land area to potentially develop a total of 24,000 MW.[33]

A recent review of this 1991 study using current methods found the main conclusions to still be valid.[34]

## 2.6 ONTARIO'S ACHIEVABLE WIND CONTRIBUTION

There are several ways to estimate what wind capacity is realistically achievable in the province. One method looks at jurisdictions elsewhere and what they have achieved; while another method examines the pace at which others are adding new wind generating capacity. First consider the case of Germany's Ostfriesland county and then that of Germany as a whole.

In 2002 there was 540 MW of wind capacity operating in the county of Ostfriesland in Germany's northern state of Niedersachsen. Ostfriesland has a surface area of 3,300 $km^2$, about one percent that of Germany, and somewhat less than one percent of the surface area of southern Ontario.[35]

Wind development in Ostfriesland continues to expand. The installed capacity will continue to increase for the foreseeable future, but at a more modest pace than in the 1990s. Even so, the capacity installed in 2002 is a good marker for comparison.

If southern Ontario, with almost 100 times the surface area, were to install as much wind capacity as Ostfriesland in 2002, there would be nearly 50,000 MW of new wind generation in the province. Even assuming a conservative annual specific yield of 600 $kWh/m^2$/year for such an extensive fleet, wind turbines in Ontario of the density now found in Ostfriesland could generate nearly 90 TWh or slightly less than 60% of total electricity consumption in Ontario.

In 2003, the 15,000 wind turbines operating in Germany were expected to produce 18.6 TWh (for comparison, about 15 commercial-scale turbines were operating in Ontario in 2003.)

As in the case of Ostfriesland, Germany continues to develop wind energy. Industry analysts expect Germany to reach 20,000 MW by 2006. If the German offshore market develops as expected, Germany could reach 30,000 MW of wind capacity by 2012.

If Ontario were able to install a similar size fleet of wind turbines delivering the same amount of generation as that of Germany in 2003, wind turbines in the province would produce 18.6 TWh per year or 13% of the province's electricity use.

## 2.7 GROWTH QUICKENS IN NEW MARKETS

Ontario has limited experience with wind energy. There are many obstacles to rapid deployment. Nevertheless, experience in Europe indicates that markets new to wind

energy take up the technology much more quickly than previous markets. The reasons are two-fold: greater accumulated experience, and larger turbines. New markets need not make the same mistakes as those that went before. New markets begin further along the learning curve than those that pioneered the technology. The turbines are more reliable, more productive, and far more cost-effective today than those of only a decade ago. Wind turbines of the mid-1990s were 500 kW in size today's machines are three or more times larger.

It took Denmark 16 years to install 2,000 MW of wind capacity, Germany seven years. Spain, a relative newcomer, took only five years. In recent additions, Germany took less than two years to install an additional 2,000 MW as did Spain. Germany installed 3,250 MW in 2002 alone.

Based on European experience, Ontario could emulate Spain in the installation of its first 2,000 MW within four years of program initiation by using today's larger, more productive wind turbines. Ontario could conceivably add an additional 2,000 MW by 2010 and double the 4,000 MW installed within two more years, reaching 8,000 MW by 2012.

Assuming the same annual specific yield as in the previous example, Ontario wind turbines could generate 7 TWh by 2010 (5% of total current provincial consumption), and 14 TWh by 2012 (10% of total current consumption).[36]

Regardless of how the wind resource of Ontario is viewed, the potential is significant and can make an important contribution to Ontario's current generating mix.

FIGURE 3 Policies that enhance stakeholder involvement are crucial to ensure active community participation in wind projects

## 3. Policies, mechanisms, and incentives to enhance wind power implementation

In nearly all jurisdictions worldwide, wind turbines operate under some kind of policy or support mechanism designed either to redress an imbalance in the marketplace, or to stimulate the rapid development of what is considered a desirable technology. Two key elements of any program are the ability to interconnect the wind turbines with the grid and some form of financial support or payment through power purchase agreements.

Various financial support mechanisms such as direct financial support (e.g. subsidies), politically set quotas (renewable portfolio standards or RPS); politically set prices (European renewable energy mechanisms or REMs) have been used with varying degrees of success. The potential and limitations of these mechanisms is discussed in the next sections.

### 3.1 PUBLIC UTILITY REGULATORY POLICIES ACT

The U.S. Public Utility Regulatory Policies Act (PURPA) is an early example of policy that tried to address both the right of interconnection and the right to a power purchase agreement. PURPA was part of the 1978 National Energy Act passed by the United States Congress. Though multifaceted, PURPA is most widely known for requiring utilities to buy power from, and sell power to, cogenerators and small power producers, the term then used for wind turbines and other forms of alternative energy. Unfortunately the rate, or price, was never specified. PURPA only described the method for calculating it. This resulted in lengthy legal challenges and regulatory rule-making that effectively stymied the hoped-for benefits of PURPA.

### 3.2 STANDARD OFFER CONTRACTS

Wind turbines are capital-intensive, long-lived forms of generation with no fuel costs. As such, investors and banks need to be assured that there is a market for the wind-generated electricity at a predictable price to justify the technical, meteorological, and political risks they assume when financing a wind project of any size.[37]

While a few wind turbines had been installed under PURPA in the United States, there was no large-scale wind development until the California Public Utility Commission (PUC) used its power to authorize standard contracts between developers of alternative energy and private electric utilities.[38] Some standard contracts offered spot-market prices.[39] One, Standard Offer No. 4 (S.O.4), offered fixed prices for a fixed number of years. Unfortunately, the PUC placed a limit on how long the new S.O.4 contracts would be offered, resulting in a rush of applications and attendant speculation. Nevertheless, the S.O.4 contracts, coupled with lucrative tax subsidies, resulted in the development of 1,500 MW of wind-generating capacity that produces about 3 TWh year; 1% of California supply, or the equivalent to 2% of Ontario's demand. And these wind turbines have been doing so for nearly two decades.

### 3.3 DIRECT SUBSIDIES

Direct subsidies based on the amount of generating capacity installed were the mechanism of choice in the Netherlands and the United States during the 1970s and early 1980s. These subsidies were widely abused, provided little incentive to generate electricity, and did little to encourage development of the technology.[40]

Subsequently, the United States adopted a federal Production Tax Credit (PTC) in 1992. The PTC is a credit against federal tax liabilities and in its present form is not transferable, that is, it cannot be passed through to limited partners. The equity owners must have the tax liability to take advantage of the credit. Thus, the PTC is useful only to the largest companies in the United States. Moreover, the PTC has a sunset provision and its expiration and eventual Congressional reinstatement have led to numerous "boom and bust" cycles in the U.S. wind industry.

There is an associated subsidy for publicly owned utilities in the United States, but the subsidy is subject to annual Congressional appropriations and is often oversubscribed.

Neither program has led to a stable domestic market for wind energy.

The Wind Power Production Incentive (WPPI) is the Canadian federal equivalent of the PTC. WPPI is lower in value than the PTC but is more egalitarian. Unlike the PTC, WPPI is a payment, not a tax credit. As such, WPPI is a more direct mechanism than the PTC. Unfortunately, use of WPPI triggers federal environmental review, increasing the cost, complexity, and length of time needed to develop a project, even if only one turbine is involved.

WPPI was implemented in 2002 and has a program life through 2007. Unlike the PTC, Canada's WPPI has a 1,000 MW limit or cap and would therefore be of limited use for a large wind deployment in Ontario.

The subsidy was initially set at 1.2 cents per kilowatt-hour (¢/kWh), but was designed to drop to 1.0 ¢/kWh for the period of March 31, 2003 to March 31, 2006, and will fall to 0.8 ¢/kWh for the period March 31, 2006 to March 31, 2007 (when the program is scheduled to expire). Like the PTC, WPPI payments continue for the first ten years of a project's life.[41]

### 3.4 INDIRECT SUBSIDIES

Deductions from taxable income are another popular incentive in North America. Canada's Renewable Conservation Expense (CRCE) and accelerated depreciation through Class 43.1 of the Canadian tax code have both been used to reduce the tax liability of investors in wind turbines installed in Ontario. CRCE allows 100% deduction of first year expenses for non-tangible items such as reports and studies.[42] More valuable are Class 43.1 deductions; one-third of the declining balance of project costs, including equipment.[43] Like WPPI, these are more egalitarian in that the deductions can be passed through to individual investors or limited partners.

### 3.5 RENEWABLE PORTFOLIO STANDARDS

In their simplest form, renewable portfolio standards (RPS) require that a percentage of electricity be supplied by renewable sources. As such, they are a politically-determined quota for the amount of renewables on a system. They are often coupled with a trading system. RPS and tradable certificates are similar to cap and trade mechanisms for air pollution abatement and have been used in several countries as electricity market liberalization swept the globe during the mid-1990s.[44]

In the trading system, each utility receives a credit or certificate for a specified amount of renewables. Utilities that fail to meet the RPS quota are fined. The value of the fines determines the upper value of the tradable certificates.

Owners of the credits can trade among themselves. Some utilities may not add any renewable capacity, instead buying the credits they need from those who do. According to theory, this results in more renewables being installed in areas where the renewables are most suited.

In some jurisdictions, the fines (sometimes euphemistically described as "alternative compliance payments") enable a utility to pay into a fund in lieu of its renewables obligation. The funds collected are then distributed by some public agency to provide "public goods" or "system benefits" that may not otherwise occur.

Renewable portfolio standards combined with trading have been used with varying degrees of success in Great Britain, Australia, Sweden, and in several U.S. states.

Many proponents of RPS programs emphasize the renewables obligation, or target, and do not specify the mechanism for reaching that target.[45]

### 3.6 TENDERING OR BIDDING SYSTEMS

Often associated with RPS programs are cumbersome tendering systems requiring prospective renewable energy providers to bid against each other for the right to a purchase power agreement or long-term contract. Often the bids are scored most heavily on price, and little value is placed on renewable energy's other attributes (e.g. regional development, employment creation, increased grid stability).

This focus on price alone is unfortunately the current direction taken by the provincial government in its Request for Proposal (RFP) to build 300 MW of new renewables.

Tendering demands a heavy administrative burden, is time consuming, and costs participants dearly. A key problem of tendering systems is that they reduce the diversity of the participants, and lead to ownership concentration in the wind industry as only the largest enterprises can gain the economies of scale needed to compete on price alone, and risk losing the costs of participating in a bid.

Another serious problem is that tendering systems greatly favour development concentration in the windiest areas, which can have detrimental implications in relation to planning, public opinion and acceptance of projects. From a systems integration point of view, this tendering system also decreases the advantage of having wind developments located over a large geographical spread (which reduces fluctuations in electricity production).[46]

In Britain a tender system known as the Non-Fossil Fuel Obligation completely failed due to gaming of the system by winners of project bids, lack of penalties for failing to install promised projects, and lack of adequate planning procedures.[47] The dismal failure of this tender system led the British government to abandon the model in favour of a trading system.

In the United States, the PTC is used to lower the bids submitted under RPS programs. However, because the PTC is useful only to those with a significant tax liability, there is no opportunity for small projects, community-owned projects, or farmer-initiated projects to compete with commercial wind developers and non-regulated subsidiaries of the electric utilities themselves. In the United States, nearly half of all new wind capacity installed in the past four years has been developed by the non-regulated subsidiary of Florida Power & Light.

In the U.S., competitive bidding systems and the unpredictable nature of the PTC have not provided a stable domestic market for wind energy as evidenced by the lack of domestic wind turbine manufacturers. Currently, only GE Wind has a manufacturing presence in the United States.[48]

To illustrate the unstable nature of the U.S. market, installed wind capacity declined 30 MW in 1997 from a total of 1,600 MW, nearly all in California. Then 600 MW were installed in 1999, the second great wind boom in the United States. The following year only 70 MW was installed. 2001 was another boom year with 1,700 MW installed, followed by only 400 MW in 2002. In 2003 another wind rush was on to complete projects before the PTC expired, resulting in another 1,700 MW.

No manufacturer can predict with any degree of certainty what the market for wind turbines in the United States will be from one year to the next. As a consequence, few can justify the investment in manufacturing assets when the utilization of those assets is so uncertain.

It is instructive to note that despite the installations in 2001 and 2003 that of the 6,400 MW in wind capacity operating in the United States at the end of 2003, nearly one-fourth had been installed under fixed price contracts written in California during the early 1980s.

The experience with the PTC and competitive bidding systems in North America and the resulting 'boom and bust' cycles contrasts sharply with that of Germany and Spain. There a manufacturing base is well-established, a skilled workforce and education networks exist to train wind researchers, developers, and installers, and this is all actively supported by a dynamic and competitive market.

### 3.7 RENEWABLE ENERGY MECHANISM (REM)

Countries leading in the renewable energy sector have followed a different path than certificate trading and tendering, a path not unlike that of California during the early 1980s. These leaders have used Renewable Energy Mechanisms (REMs) instead.

As explained in the introductory chapter, REMs evolved from the original electricity feed-in laws enacted by Denmark and Germany.

REMs facilitate the interconnection of wind turbines with the electric-utility network and at the same time specify how much the wind turbine owners are paid for their electricity.[49]

The REM systems currently in place in Germany and Spain are the single most successful mechanism for stimulating the rapid development of wind turbines.

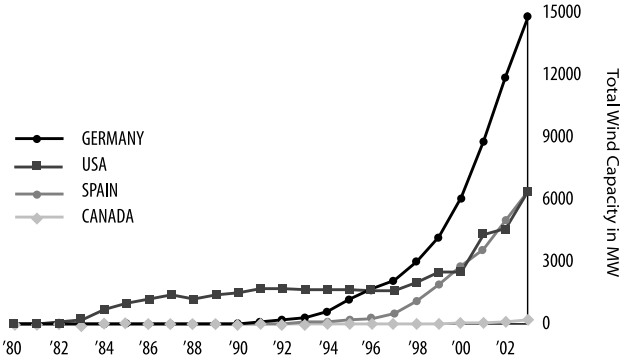



FIGURE 4 Despite the size of its market and its initial lead in wind development, the United States has fallen far behind the meteoric rise of German wind development. Germany leads the world in wind development as a direct result of its renewable energy mechanisms. Similarly, Spain, which also uses renewable energy mechanisms, now rivals the United States. Canada is still trying to find its way forward.

No other renewable energy support mechanism has produced more renewable energy than the original German feed-in laws and the subsequent introduction of REMs. There were more than 14,000 MW of wind-generating capacity operating in Germany at the end of 2003. This is a fleet capable of producing 18.6 TWh annually, the equivalent of more than 10% of Ontario's current electricity use.

The fixed-price, long-term contracts that result from REM have spawned in Germany and Spain dynamic markets with several wind turbine manufacturers, and a host of suppliers.

During the years that Denmark relied on REMs, the resulting stable markets helped local wind turbine manufacturers to become world leaders in the technology.

Through the mid 1990s, Denmark's 2,100 wind cooperatives accounted for one-half of the nation's total installed wind capacity. Some 100,000 Danish households, or nearly 5% percent of the population, own a stake in a cooperatively-owned wind turbine. Furthermore, farmers own many of the remainder turbines.

As a legacy of its experience with REMs, 20% of all the electricity used in Denmark today is generated using wind turbines.

REMs are more egalitarian than almost any other support mechanism, enabling communities, cooperatives, and farmers, as well as commercial wind power developers, to participate in the rapid expansion of renewable capacity. Renewable mechanisms offer opportunity to many players, and offer farmers a potentially new cash crop – wind-generated electricity. Moreover, REMs create a dynamic market, which is essential to encourage domestic manufacturing.

The fixed-price contracts under REMs also reduce price volatility from utility purchases in the spot market, helping to ensure price stability.

## 4. Conclusions and further research

Ontario has a significant wind resource. What is needed is the political will to implement the technology. Wind energy could deliver as much as one-third of Ontario's present supply. Near term, wind energy could contribute nearly 10% of current supply by 2012 if political commitment toward renewable energy is expressed and new policy mechanisms are put in place quickly to make this happen. The mechanism most likely to succeed in stimulating rapid deployment of wind energy in Ontario is renewable energy mechanisms similar to those used so successfully in Germany.

Issues that additional research may help clarify include: how best large amounts of new renewable capacity can be integrated into the Ontario network, and more detailed mapping of the province's onshore and offshore wind resources and zones of exclusion.

There is little need for additional research into the technology of wind turbines themselves. Wind turbines

are sufficiently advanced and large-scale deployment can begin immediately. However, questions remain about a programmatic wind assessment, which would be valuable for identifying public concerns as well as to identify areas where wind energy is not suited. A programmatic environmental assessment would examine the effects from phased development and from full build-out of Ontario's wind potential. This would obviate today's piecemeal approach that places a burden on wind projects of any size, while offering little overall perspective on wind energy's cumulative effects.[50]

Likewise, there may be other social and technical issues of concern that while studied elsewhere – often at length – Ontario may well want to evaluate under provincial conditions such as: public perception of wind development, noise propagation, and visual intrusion.

The resource analysis used in this report is based on the experience of wind development in several leading countries, notably Germany.

However, it would be valuable to identify southern Ontario's wind resource on a one-kilometre by one-kilometre grid overlaid with zones of exclusion for roads, villages, parks, wildlife sanctuaries, military bases and over flight zones, and unique natural features. From this a far more accurate picture of Ontario's wind potential can be identified. Although such analysis is beyond the scope of this report it must be emphasized that there is no need to wait for such a study before beginning commitments for large-scale wind deployment to make a significant contribution to Ontario's energy future.

### RIDING THE WIND IN CALGARY

Calgary, Alberta, is home to the first public light rail transit system in North America powered by wind-generated electricity.

The fleet of 116 trains, which run along more than 38 kilometres of track and 36 stations, are all powered by 12 windmills located in southern Alberta. The power generated by the windmills is sent to the main power grid.

By using wind power to run the trains, the city of Calgary reduces carbon dioxide emissions by 26,000 tonnes each year – equivalent to eliminating 7.5 million vehicle trips in Calgary each year.

In 2001, Calgary Transit partnered with ENMAX and Vision Quest Windelectric to develop a program called "Ride the Wind!" that uses wind-generated electricity to power its C-Trains.

Since its inception in 1981, the C-Train has increasingly become a popular mode of transportation for Calgarians. More than 200,000 people ride the C-Train every weekday – representing a 93 percent increase in ridership since 1995.

The downtown area is a free fare zone in which it is free to ride the LRT, however a fare must be paid if you are traveling outside the downtown area. Rush hour service has a five-minute frequency and off-peak service is reduced to 15-minute service.

## WIND CHAPTER NOTES

1 The role of small or household-size wind turbines in Ontario is not discussed here. For information on small and household-size wind turbines and how they are used see Gipe, P. (2004). *Wind Power: Renewable Energy for Home, Farm, and Business*, White River Junction, Vermont: Chelsea Green Publishing. Readers interested in understanding more about wind power are encouraged to examine the "guided tour" of the Danish Wind Industry Association at www.windpower.org

2 Gipe, P. (1995). *Wind Energy Comes of Age.* New York: John Wiley & Sons.

3 All statistics presented here are derived from numerous sources, including but not limited to national trade associations and BTM-Consult's Wind Market Updates, published annually, and the author's own records. Amidst the growing politicization – and commoditization – of statistical information on the wind industry, BTM-Consult's reports are the reference source for independent data on the development of wind energy worldwide.

4 Note that analysts track the industry's growth using installed power in MW, simply because it is the easiest number to gather as each turbine is nominally rated by the size of the generator it carries. The amount of electricity that a wind turbine produces is directly related to the wind resource and the area swept by the wind turbine's rotor, and only indirectly by the size of the generator.

5 BTM-Consult (2003). *World Market Update*. Available at: www.btm.dk

6 Robert Hornung, CANWEA, personal communication

7 Bundesverband Windenergie, Arbeitsplatzstatistik der Windenergie-Branche für das Jahr 2003, Osnabrück, Germany, background information, 18.02.2004, cites Deutsches Windenergie Institut (DEWI).

8 Sørensen, M. (1997). Learning curve: how are new energy technology costs reduced over time? Report of IEA Workshop: Energy Technology Availability to Mitigate Future Greenhouse Gas Emissions. Paris: International Energy Agency. See also Ackermann, T. Söder, L. (2000). Wind energy technology and current status: a review. *Renewable and Sustainable Energy Reviews*, 4, 315–374.

9 See EWEA. (2000). *Proceedings of the EWEA Wind Power for the 21st Century Conference*, Kassel, Germany especially papers from Schleswag AG, a utility with probably the largest penetration of wind energy in the world.

10 For example, according to page 48 of Electricity Conservation & Supply Task Force. (2004). *Tough Choices, Addressing Ontario's Power Needs: Final Report to the Minister.* Available at www.energy.gov.on.ca/english/pdf/electricity/TaskForceReport.pdf "Intermittent generators can be valuable as a source of energy for load displacement, but their inherent unpredictability does not allow them to be used for baseload or peaking purposes."

11 See chapter 17 'System Integration' by E. Bossanyi in Freris, L. (1990). *Wind Energy Conversion Systems.* London: Prentice Hall.

12 Smith, D. (1990). Wind energy resource potential and the hourly fit of wind energy to utility loads in Northern California. In *Proceedings of Windpower 90, the Annual Conference of the American Wind Energy Association.* Washington, DC: AWEA,

13 Kirby, B., Milligan, M., Makarov, Y. Hawkins, D., Jackson, K. and Shiu, H. (2003). *California Renewables Portfolio Standard Renewable Generation Integration Cost Analysis.* Report prepared for the California Energy Commission and the California Public Utilities Commission. Available at: http://cwec.ucdavis.edu/rpsintegration/RPS_Int_Cost_PhaseI_pubrev1a.pdf

14 Giebel, G., Gylling, N. and Czisch, G. (2003). *Effects of Large-Scale Distribution of Wind Energy in and around Europe.* Report Available at: http://www.iset.uni-kassel.de/abt/w3-w/projekte/Risoe200305.pdf

15 Cold winter air contains as much as 15% more energy than that at a standard temperature of 15° C.

16 These are not "full-load hours" as used in Europe to describe productivity, merely the number of hours when the wind turbine is generating electricity and not a measure of how many hours the turbine operates at full rated capacity.

17 According to Page 57 of Electricity Conservation & Supply Task Force. (2004) op.cit. note 10: "One option that could be attractive is the banking of power with Quebec or Manitoba, allowing those markets to store water and generate more power when it has higher value."

18 According to Page 50 of Electricity Conservation & Supply Task Force. (2004) op.cit. note 10: The advantages of using wind power include: speed of installation (6 months to a year after permitting is complete), no fuel cost, stable generation cost, and a strong correlation to electricity requirements (installations produce more power in winter and during the day).

19 For more information about the additional benefits of wind energy see note 1.

20 Using this calculation (described in page 6 of Kammen, D.M., Kapadia, K, and M. Fripp (2004) *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* RAEL Report, University of California, Berkeley. Available at http://ist-socrates.berkeley.edu/~rael/renewables.jobs.pdf) The person-years estimate can be divided by the average life of the wind facilities (e.g. 20 years) resulting in 5,000 jobs for 8,000 MW of wind turbines

21 Helimax. (2004). *Étude sur L'Évaluation du Potentiel Éolien, de son Prix de Revient et des Retombees Économiques Pouvent en Déouler au Québec, Dossier R-3526-2004*. Montreal: Hélimax. Available at: http://www.helimax.com/dossier_r35262004.pdf For 1,000 MW: 6.7 person-years/$1 million; 121.5 person-years/TWh for operation. For 4,000 MW: 7.7 person-years/$1 million;

107.9 person-years/TWh. It's not clear from the text why there would be more people employed per dollar invested at 4,000 MW than 1,000.

22 Assuming 4,000 MW installed at the rate of 1,000 MW/yr and operating for 25 years, the German employment values would produce about 97,000 person-years, versus the estimate of 78,000 person-years by Helimax (2004) op.cit. note 20.

23 Ibid.

24 See Gipe, P. (2004) op.cit. note 1.

25 While legally permitted to do so, the requirements are so onerous, the process so complex, and the payment for their electricity so meager that it is impractical.

26 Farmers bear the risk that the developer may not succeed in winning a bid to supply power to the province, locking up the farmer's land for a period of time. Worse, the developer may "flip" the lease and sell the rights to another firm not party to the original transaction.

27 5% value from personal communication with German wind development engineer Henning Holst; 4%, 6%, 8% per succeeding decade from Texas Land Commission, Indian Mesa project, as reported by the Alternative Energy Institute, West Texas A&M University, Canyon, Texas. 3.8% for the first 15 years, 5.4% after from a prospectus for a Bürgerbeteiligung in the German state of Baden-Württemburg. Ontario offers vary from 2% to 2.75%.

28 The 1-MW turbine is used here only to illustrate the potential. Many wind turbines today are larger.

29 Political risk is not insignificant in Ontario. Pioneering wind turbines installed at great expense under past policies initiatives have been stranded by political changes in the province. Recurrence of that problem will hurt financing of future projects.

30 The best example for the necessity for such studies is Buffalo Ridge, Minnesota. In national wind resource studies the area of Buffalo Ridge, a gentle rise in the southwestern corner of the state between the drainages of the Mississippi and Missouri Rivers, was classed as only a modest resource. The state of Minnesota conducted a decade-long wind resource assessment and in so doing discovered a powerful, but overlooked, wind resource. Today there is 550 MW of wind capacity operating in the vicinity of Buffalo Ridge.

31 The common practice in the electric utility industry is to represent generating capacity in megawatts (MW). While this nomenclature is useful when comparing similar sources of generation or for the amount of instantaneous capacity needed to meet demand, it is less so when describing potential resources and especially intermittent resources without energy storage, such as run-of-the-river hydroelectric and wind generation. As a result, Ontario's potential wind resource is described in terms of energy in TWh and not MW.

32 Ontario Wind Power Task Force. (2001). *Industry Report and Recommendations.* Available at www.newenergy.org/Wind_Power_Task_Force_Report,_February_2002.pdf.

33 The study estimated that the wind resource could be used to generate about 18 TWh of electricity annually (the significantly lower generation estimate is due to the fact that the study used 1991 wind turbines). The study was carried out by R. Lynette and Associates for public hearings on the Ontario Hydro 25-Year Demand/Supply Plan of 1991 and it used a sophisticated approach to estimate the acceptable potential for wind energy in the province.

34 This estimate uses data and an analytic approach provided by Jim Salmon, Zephyr North, Burlington, Ontario.

35 Note that analysts track the industry's growth using installed power in MW, simply because it is the easiest number to gather as each turbine is nominally rated by the size of the generator it carries. The amount of electricity that a wind turbine produces is directly related to the wind resource and the area swept by the wind turbine's rotor, and only indirectly by the size of the generator.

36 Calculation assumes a capacity factor of 20%.

37 In arguing the case for nuclear power, the Supply Task Force noted its capital intensive nature and as a result nuclear's need for fixed-price contracts. "Long-term supply contracts provide the best mechanism for ensuring price stability" see Electricity Conservation & Supply Task Force (2004) op.cit. note 10.

38 For an exciting account of leaked documents, power politics, and how California became the one-time hotbed of renewable energy development see Roe, D. (1984). *Dynamos and Virgins.* New York: Random House.

39 All the companies that opted for this contract went bankrupt within a few years.

40 For more details see Gipe (1995) op.cit. note 2.

41 Tampier, M. (2004). *Background Document for the Green Power Workshop Series*, Toronto: Pollution Probe and Summerhill Group.

42 Ibid.

43 Ibid.

44 For a discussion of the pros and cons of politically-determined amounts and politically- determined prices see pages 18–23 of Hvelplund, F. (2001). *Political Prices or Political Quantities? A Comparison of Renewable Energy Support Systems.* Osnabrück, Germany: New Energy. Available at http://www.ontario-sea.org/REMs/EFLFredeHvelplundBerlin 2002.pdf. Hvelplund's book examines this topic in more detail. See Hvelplund, F. (2001). *Renewable Energy Governance Systems: A Comparison of the "Political Price-/Amount Market" Model with the "Political Quota-/Certificate Price Market" System (The German and Danish cases)*. Aalborg University: Institute for development and Planning.

45 Wiser, R., Porter, K., Bolinger, M. (2002). *Comparing State Portfolio Standards and System-Benefits Charges Under Restructuring.* Berkeley: Lawrence Berkeley National Laboratory. Wiser has written extensively on Renewable Portfolio Standards and his work, and that of Mark Bolinger are available on the LBNL web site, http://eetd.lbl.gov/ea/EMS/cases/

[46] Kjaer, C. (2004). Support Mechanisms. Brussels: European Wind Energy Association. Available at www.ewea.org/documents/supportmech.pdf

[47] ibid.

[48] GE Wind also manufactures wind turbines in Germany.

[49] For detailed information on REM see www.ontario-sea.org/REMs/REMsList.html

[50] Using the federal Wind Power Production Incentive triggers a federal environmental assessment for a project as small as one turbine. Similarly, Ontario's current trigger for a provincial environmental assessment is 2 MW. Many wind turbines today are 2 MW or larger.

# 3 Hydroelectricity in Ontario

## Summary

Hydroelectric facilities provide a clean and low-cost source of energy that meets more than a quarter of Ontario's electricity requirements.

Ontario's hydroelectric industry currently generates $1.7 billion in annual energy production and supports 3,600 jobs. Plant operators invest approximately $250 million in operating and maintenance budgets and contribute $140 million annually in water royalties to the government.

The past decade has seen a small increase in the number of hydropower development projects in the province, with only 150 MW of new capacity being installed as a direct result of $400 million in long-term capital investment.

Ontario has over 2,000 potential hydropower sites, of which only 200 have been developed. Ontario has the option of developing and refurbishing an additional 1,000 MW of small-scale and low-impact hydroelectric sites.

Using a conservative estimate for job creation, this additional hydroelectric potential could increase current employment in the hydroelectric sector by about 7% (accounting for an additional 240 jobs in the province).

Although this estimate indicates that the technology has a lower employment creation potential than other renewable options, many new hydroelectric facilities can be located in parts of Ontario currently facing economic hardship and chronic underemployment. Small, low-impact hydroelectric facilities in particular are especially well-suited for community development purposes because they can create employment, increase economic activity and protect local energy security. Renewable energy mechanisms can be tailored to facilitate the development of these facilities.

Ontario's existing hydroelectric facilities have ample potential to also support the 8,000 MW of wind facilities recommended for development by this study. The province's installed dispatchable and storage-based hydroelectric facilities have many times the capacity to support and help integrate the proposed wind development.

Integrating significant wind resources into Ontario's electrical system is not constrained by technological challenges. Although detailed technical assessments need to be conducted, the key obstacles are political and financial in nature. What is needed is cooperation between existing hydroelectric facilities and new wind facilities, and political will to create a financially acceptable operating platform.

## 1. Background on hydropower

The transition from the age of steam to a modern electrical society has deep roots in Ontario. Starting in the late 19th century, hydroelectric generation powered Ontario's economic engine and helped develop one of the wealthiest regions in North America.

As technology evolved, cities and towns located near suitable sources of waterpower quickly traded in their water wheels for hydraulic turbines. In 1883, Ottawa was one the first cities in North America to light its streets using renewable energy from the Ottawa River.

With the advent of alternating current and transformer technologies, high-voltage transmission lines were developed. This allowed energy to be transmitted over long distances, a necessity when considering that suitable hydraulic resources are rarely located near urban load areas.

From these early beginnings, Canada has grown to become one of the leading hydropower producers in the

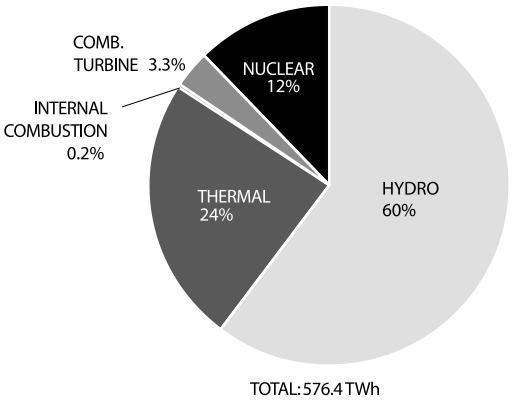



FIGURE 1 Canada's electric power generation (2002)
Source: Statistics Canada

world. Today, Canada has about 450 hydroelectric plants, representing a total installed capacity of 67,000 MW, which provide 60% of the Canadian electrical supply mix.

At the end of 2003, Canada had an additional 2,400 MW of additional capacity under construction, 600 MW of refurbishment projects, and more than 6,200 MW of hydroelectric development in the planning stages.

Although Canada is a major developer of hydropower, what is not usually specified is how much of this renewable energy technology is low-impact environmental technology.

Large hydroelectric facilities require costly, custom, detailed engineering programs and environmental assessments due to the physical size of the plants and the environmental damage resulting from reservoir flooding, sedimentation, destruction of fish and wildlife habitats and concerns about greenhouse gas emissions.[1]

Small-scale hydroelectric development requires comparatively little physical space while only occasionally causing more local ecosystem damage than natural flooding, drought, and erosion rates present prior to plant commissioning. Many negative environmental impacts can be avoided by good design, involvement of local landowners and appropriate construction and operating practices.

The Canadian Environmental Choice Program offers Ecologo Certification for qualifying renewable, environmentally low-impact electrical generators and can be used as a guide to minimize the environmental damage of a hydroelectric development.[2]

At the end of 2003, there were 224 small hydro plants operating in Canada with a total installed capacity of 996 MW. An additional 53 MW of capacity are now under construction or in the late planning stages.

Ontario's 50 river systems provide the energy to power 8,150 MW of installed hydroelectric capacity.[3] Ontario Power Generation (OPG) owns the vast majority of this capacity, controlling 36 large-scale facilities with an installed capacity of 6,796 MW. In addition, OPG owns a further 29 EcoLogo certified green power sites with a capacity of 125 MW.[4] The remaining 1,229 MW of hydroelectric capacity are provided by Non Utility Generators (NUGs).

According to OPG statistics, low-impact hydro accounted for approximately 95% of its 2002 green power generation, providing approximately 700 gigawatt hours of electricity (sufficient to supply the annual needs of about 60,000 Ontario homes).

## 1.1 WORLDWIDE HYDROPOWER DEVELOPMENT

Hydropower generates about 17% of the world's electricity; however, due to the fact that most countries use different definitions for determining small hydroelectric facilities it is not feasible to provide a definitive estimate of the total world installed capacity of small-scale hydropower.[5]

Nevertheless, country-specific information is readily available and indicates that countries in all continents are stepping up their deployment of small-hydro facilities.[6]

## 1.2 HYDROPOWER IS AN ESTABLISHED BUSINESS

Hydropower accounts for nearly $1.7 billion in annual energy production in the province. Water leases total more than $140 million a year, the largest single source of natural resource-based income paid to the province.

Outlining a specific range of capital costs is difficult due to the site-specific nature of projects. Nevertheless, private developers indicate an average range of $1.5 to $3.0 million per MW of installed capacity.[7]

Sites that do not require long penstocks or canals, roads or bridges can have a large effect on first-time costs (costs that are not directly related to the capital necessary for power production). Under favourable conditions, systems may be installed for as little as $1,000 per kW.[8]

In the past decade, the development of 150 MW of hydropower capacity in Ontario resulted from an investment of $400 million or $2,670 per kW capacity.[9]

Small projects have similar assessment and engineering issues to large projects, but small developers often have lower overhead costs. Additionally, run-of-river systems do not require large reservoirs or catchment structures, driving first-time costs downward.

From an income statement point of view, small developers appear to stand on equal ground with their large project counterparts. Industry figures indicate that EcoLogo certified sites can generate power with a suitable return on investment in the $55 to $65 per MWh range, which is comparable to new large-scale projects.

## 1.3 TECHNICAL CONSIDERATIONS

Well-planned hydro generation sites are designed to use as much of the flowing water as possible, without harming the local ecosystem.

Seasonal variations in water flow may prevent a site from running continuously or at its rated capacity (nameplate rating). The ratio of actual yearly energy production to total potential energy production, given the nameplate rating of a power plant, creates a de-rating coefficient for the station known as the capacity factor. The capacity factor for sites in Ontario varies widely and sites with reservoirs operate at higher capacity factors than run-of-river units.

Established hydroelectric sites with significant reservoir capacity can store water and provide dispatchable energy, which may be utilized to provide electricity during peak use times and also to offset the intermittent nature of other renewable resources (in essence acting as a large battery that can be turned on and off as needed). These latter sites are known as peaking plants, resulting from their inherent flexibility of supply.

Run-of-river hydroelectric sites do not have significant reservoir capacity and therefore have lower capacity factors than sites with reservoir storage. These plants have two key constraints: first, the hydroelectric site must be operated continuously at or near maximum output coincident with available water resources (i.e. as a baseload facility); and second, plant capacity must be overbuilt to compensate for the lack of reservoir. Baseload plants are not dispatchable, operating with lower economic value than dispatchable, peaking facilities, although at a greater value than intermittent supplies.

Capacity sustainability is a concern when peaking hydroelectric generation is operated extensively (for example, as a result of high electricity demand in hot, dry periods or in response to pressure to sell energy during a lucrative spot market). If this operating mode continues over a period of time, storage water levels may prove insufficient to meet generation demand. The province is susceptible to this energy constraint as a quarter of total electricity use depends on hydroelectricity.

Hydroelectricity generation can be divided into four broad categories: micro, mini, small, and large-scale. Micro and mini-scale units are used in individual applications and small communities. Small hydro systems feed baseload (generally non-dispatchable) electricity into the distribution or transmission grid. They are designed to capture the energy of flowing water directly, without the need for water impoundment and large dams. Large hydro requires the construction of large dams and reservoir areas, which store potential energy and provide valuable dispatchability.

There is no international consensus on the definition of small hydropower and many countries use turbine or station capacity as the defining measure.[10]

Small hydro facilities can be connected to either the high-voltage transmission system or a local distribution system. Connecting these smaller renewable generators to the distribution grid does not result in significant impacts to the electricity system.

However, Ontario's interconnection rules to the distribution system are not harmonized, resulting in a mix of confusing rules and regulations throughout the province.

Harmonizing these rules is an essential step to facilitate the implementation of new small hydroelectric facilities. In addition, the development of simplified protection and interconnection norms should also be provincial priorities to enhance the widespread adoption of these systems.

## 1.4 INTEGRATING EXISTING HYDROELECTRIC FACILITIES WITH NEW WIND PLANTS

Wind energy and some other forms of renewable energy are intermittent, to some extent predictable, but nonetheless variable over time. In this regard, wind energy is not unlike run-of-the-river hydroelectric or solar photovoltaic systems where their generation responds to the flow and natural cycle of the resource.

Studies in the United States and Canada have shown that the coordination between wind generation and electric utilities can be beneficial to both. The addition of wind generation to an electric utility can improve the economic performance of the electric utility system when operated in a coordinated manner.[11]

The addition of wind power facilities to regional electricity networks can be facilitated by releasing the storage of hydroelectric reservoirs during peak demand times, which maximizes the value of the hydro resource

that may have otherwise been released earlier to meet average demand.

In essence, the grid operator can use available hydro storage as a 'battery' that allows for accumulation of water when there is an excess of wind-generated electricity, and to release this stored water to produce electricity when it is most needed.

A study examining the relatively small network serving Vermont found that it was possible to add a large amount of wind generating capacity because of good regional ties with Hydro Québec and Vermont's neighbours in the New England Power Pool (NEPool).[12]

Modeling conducted for the study determined that the integrated system could absorb a penetration of 58% wind within Vermont (i.e. 810 MW of wind in Vermont's 1,400 MW system). The model assumed that the network was operated optimally to absorb as much intermittent wind capacity as possible. The study concluded that the integration of wind energy with hydroelectric generation can improve the management of the hydro reservoirs, increasing the value of wind generation, and the availability of hydroelectric storage.

Further elaboration of the relationship between a high concentration of wind generation in Vermont and its integration with Hydro Québec's network calculated that operating the two synergistically increased the value of wind energy by more than one-fifth above the price wind energy would command on the NEPool system.[13]

These studies illustrate how to resolve a common misperception that wind-generating capacity requires an equivalent amount of capacity in reserve as a backup. In fact the intermittent nature of wind energy is simply another uncertainty that the pool's elasticity can handle.

At first glance it often appears that an equivalent amount of fast-response, or on-demand generation must be available to back up intermittent resources, such as when winds are light or variable. This observation has unfortunately become a common and widely-entrenched mistake.

Studies and operating experience from utilities in the U.S. indicate that the amount of reserve capacity required to integrate an incremental 1,000 MW of wind generation can be as little as 100 MW (or 10% of nameplate capacity).[14]

It must be emphasized that this figure has a considerable range. Therefore, the province needs to instruct provincial system operators, wind and hydroelectric researchers, and energy analysts to conduct a detailed study to determine and clarify how large-scale wind generation can interact with the unique characteristics of Ontario's hydroelectric system.

Although Ontario needs to develop its own estimate of wind-hydro integration using province-specific planning methods, the aforementioned figure provides indication that large-scale wind integration can be achieved at relatively small cost, especially for hydro systems with flexible reserves and considerable surplus capacity.

Integration of intermittent renewables with dispatchable hydroelectric storage in essence creates a synergistic relationship between the two, for example, by increasing the capacity value of wind resources.

## 1.5 THE EFFECT OF INTERMITTENT GENERATION

Grid operators must constantly balance supply and demand on the system in real-time. They have limited day-to-day control over demand, which is determined by their customers, although there are ways to significantly influence this overtime through support for energy management and demand side management programs. Therefore, system operators have traditionally focused on controlling supply – adding or removing generating capacity as required.

There are special challenges facing electricity system operators who want to balance power from intermittent sources like wind, where they can't decide how much power will be added, and when, but have to accept what the prevailing winds bring them. Yet these challenges can, and have, been met in jurisdictions with significant wind power integrated into the system. It is worth noting that there are also challenges with nuclear power, which can require days or weeks to be brought on–line.

In order to smooth out the variability of wind and other intermittent supply sources, dispatchable generating plants are required. Hydroelectric generation facilities provide a means of varying their energy output on a moment-by-moment basis, effectively "filling in" the dips from intermittent sources such as wind energy. Excess dispatchable generation must also be present in order to absorb energy, (i.e. by reducing energy production) should wind generation production exceed instantaneous system demand.

The Bonneville Power Administration (BPA) in the U.S. Pacific Northwest, for example, is currently offering a number of services that offer proper management of the above issues by using its hydroelectric dispatchable capacity for wind regulation purposes. BPA uses the

flexibility of the Federal Columbia River Power System to integrate wind energy on behalf of other utilities with an interest in purchasing wind power.[15]

## 1.6 BENEFITS OF NEW HYDROPOWER DEVELOPMENT

The costs and benefits of large hydroelectric projects have been well documented.[16] However, the potential benefits of small-scale hydro are usually less understood.

Hydropower development in many cases involves undeveloped sites on rivers (or existing dams without turbines) that are not necessarily near the load, which implies that grid extensions will be required to transmit the power over some distance. Therefore, this chapter concentrates on the potential of developing a multitude of smaller hydroelectric sites (which require lower voltage transmission lines than large hydroelectric plants) and refurbishment of existing sites.

Large hydroelectric systems require connection to the high-voltage grid, which is extremely expensive.[17] Small hydro systems may be connected to either the low-voltage or medium-voltage distribution system, or may be connected to the high-voltage transmission system located a distance away (that is, the generating station may transmit a medium voltage and be stepped up upon arrival to a sub-station).

Small hydroelectric plants can generate the majority of power needed for consumption at local sites. For example, the Abitibi Consolidated pulp and paper mill in Fort Frances, Ontario has a dozen 2 MW small hydro generators which feed the mill first and the local community secondly without the need for a high-voltage transmission system. The design and placement of the distribution/transmission system is site specific.

Furthermore, large centralized generation facilities concentrate investment in one area. Decentralized generation of the same capacity over many sites distributes investment on a more democratic basis and can lead to employment gains and local development.

## 1.7 EMPLOYMENT

Ontario has approximately 200 operating hydropower facilities, of which half are located south of the French and Mattawa rivers. The northern half of these stations are situated in areas that support forestry and mining operations; key contributors to the economies of northern communities.

The operation and maintenance of these facilities directly employ 1,600 people and provide indirect support to a further 2,000 people. Ontario's 60 hydropower producers invest approximately $250 million annually in support of these facilities.

Using a conservative employment estimate, development of 1,000 MW of small-scale and low-impact hydroelectric sites in Ontario could result in an estimated increase of 240 jobs in the province.[18]

In addition to jobs directly related to generation and support, an unknown number of spin-off jobs could be created. These new jobs could be created from combining hybrid renewable/fossil fuel systems for remote communities, developing advanced software and hardware systems to integrate hydro and wind, and other supporting technologies.

## 1.8 LOCAL ECONOMIC DEVELOPMENT

Many new hydroelectric facilities can be located in areas that suffer from under-employment and could be a source for new skilled full-time plant operation and maintenance jobs. In addition, approximately 15 to 20% of project capital is spent in the site development area.

FIGURE 2 Environmentally low-impact hydro sites require careful site planning and deployment. The Appleton, Ontario Ecologo-certified plant owned by Canadian Hydro Developers is a run-of-river, 1,350 kW site comprising 2 propeller and 1 Kaplan turbine. Construction was intended to blend into the surrounding residential area by keeping the powerhouse low to the upstream view, preventing obstruction of the historic mill ruins.

Furthermore, for remote or northern communities, the economic and environmental benefits of new hydropower development can be significant. Approximately 300 Canadian northern and First Nations communities currently rely on decentralized diesel generation, a source of greenhouse gas emissions. Diesel fuel is an expensive commodity that must be shipped over long distances, often covering environmentally-sensitive areas. The risk of spillage due to accident or leakage is

considerable. In areas where sufficient hydraulic resources are available, complete removal of diesel generation is possible. In areas with less favourable resources, hybrid systems that combine the operation of diesel generators and small hydro plants can be used to reduce fuel costs and emissions.

## 2. Ontario's hydroelectric resources: key foundation of provincial power

Ontario is blessed with a large number of lakes and rivers, which at first glance should provide an unlimited amount of hydroelectric generating capacity. However, for a given site to be technically viable, it must have sufficient flow and hydraulic head or vertical drop. During the first half of the 20th century, Ontario Hydro developed the majority of these accessible sites, leaving aside those with less than ideal development potential. Nevertheless, our analysis indicates that significant hydroelectric potential exists from refurbishing existing hydroelectric facilities and new sites.

### 2.1 ESTIMATES OF ONTARIO'S TOTAL HYDROELECTRIC RESOURCES

The Canadian Hydropower Association (CHA) estimates that Ontario's total additional hydroelectric potential is more than 5,000 MW.[19]

The Ontario Waterpower Association (OWA) has estimated that Ontario's hydroelectric potential totals from 1,200 to 2,000 MW (from re-development, upgrades, and new development).[20]

Surveys conducted over the past 20 years indicate that Ontario has approximately 2,190 feasible sites for development. Unfortunately, two major site assessments conducted for the Ontario Ministry of Natural Resources (MNR) and the International Energy Agency (IEA), concur on the number of sites, but differ greatly on their capacity. For example, the MNR database indicates a total potential resource of 6,046 MW while the IEA database, which focuses on small hydro (<30MW), provides a total of 2,193 MW.[21]

Given the large number of sites and limited hydrological survey data, estimates are subject to considerable error. For example, consider that the MNR database indicates that Freighters Dam on Ahmic Lake is tabulated with a 750 kW capacity rating but has in reality zero head and flow.

While these compilations may be of limited use for determining actual site capacities, the database does provide prospective developers with geographical coordinates for locating potential development sites.[22]

Pivotal research conducted in 1990 by Ontario Hydro remains today as a unique and crucial source for an overview of the hydroelectric resources available in Ontario.[23] That research placed Ontario's total theoretical hydroelectric potential at 19,900 MW. Deducting existing developed capacity from that theoretical potential would indicate that a maximum of 12,400 MW remains as undeveloped potential.

**TABLE 1**

Ontario's potential hydro resource

| Source | Estimated resource potential (MW) |
|---|---|
| M.N.R. | 6,046 |
| I.E.A. | 2,193 (small hydro only) |
| Ontario Hydro | 12,400 |
| CHA | > 5,000 |
| OWA | 1,200–2000 |

Note:
MNR is Ministry of Natural Resources
IEA is International Energy Agency
CHA is Canadian Hydropower Association
OWA is Ontario Waterpower Association

As Table 1 indicates, there are significant discrepancies between available data sources, which clearly suggests that a new collaborative research effort between the provincial government and the hydroelectric industry is imperative to identify and clarify Ontario's hydroelectric resources. Until such research is conducted, the data presented in this report must be considered as a preliminary and rough attempt to quantify Ontario's hydroelectric resource.

The wide discrepancy between the Ontario Hydro estimate and those of MNR, IEA, and CHA clearly suggest that deductions for several constraints have to be factored into the Ontario Hydro data. A variety of social, economic and environmental considerations influence the viability of potential hydropower deployment in the province. The next sections analyze the impact of these variables in Ontario Hydro's estimate of hydroelectric potential.

### 2.2 TECHNICAL RESOURCES

The potential exists to upgrade existing sites, which includes improved turbine runner and generator technologies. There have been no definitive studies completed on this potential, although the Ontario Waterpower Association (OWA) estimates that there is potential for 1,350 MW of increased capacity.[24]

FIGURE 3 Repair and refurbishment of older hydro generating plants is a viable opportunity for non-utility generators in the province. This plant, constructed in 1906 and located in Galetta, Ontario, was originally developed with 2 x 400 kW synchronous generators. Upgrading the turbines and maximizing water resources has doubled plant capacity from 800 kW to 1,600 kW. (Courtesy of Canadian Hydro Developers and Powerbase Automation Systems Inc.)

Numerous other sites totaling 1,784 MW capacity are excluded from Ontario Hydro's total resource estimation because they lack adequate data regarding soil structure, hydrology, and environmental impact information.

## 2.3 PRACTICAL RESOURCE

Although there is no shortage of sites that could be developed, many of these are in Ontario's far north: the Albany and Attawapiskat Rivers which flow into James Bay, and the Winisk and Severn flowing into Hudson Bay. Complicating matters is the flat terrain of this region, which possesses few rapids or falls of significant magnitude, necessitating large dams which would cause extensive flooding of virgin territory. Furthermore, these dams could result in displacement of First Nations communities and destruction of ecosystems in the watershed areas. Therefore, it is estimated that 5,000 MW of capacity must be discounted from this study for these reasons.

Other site upgrades considered suitable for development include four facilities on the Ottawa River: Chats Falls, Chenaux, Des Joachims and Otto Holden. Such updates would add 796 MW of peaking capacity, while generating only 0.33 TWh of energy per year. Concerns about poor peaking and energy characteristics coupled with fluctuations in water flow on the Ottawa River led us to exclude this capacity from the current resource estimation.

## 2.4 ACCESSIBLE RESOURCE

The creation of 53 new provincial parks in 1988 prevented development of ten large hydropower sites, with a capacity of 694 MW. This constraint is a public policy issue that could be reversed or modified to allow site development. In the interim, this capacity must be discounted from this study.

An indication of potential change in this area came in early April 2004 when Provincial Natural Resources Minister David Ramsay stated in a press release that the government will open up Crown land so companies can build wind farms and small water-powered electricity plants.[25]

Accessibility plays a factor in the development of remote sites, where economics and infrastructure development, such as roads or grid extensions, are essential considerations. However, there are currently no recorded economic data on accessibility on which to base an assessment. Government and industry as part of the resource assessment recommended above should also undertake a cooperative study reviewing the impact of these issues.

## 2.5 ACCEPTABLE RESOURCE

Allowing for constraints in the Ontario Hydro data results in a resource potential of 4,126 MW, which is comparable to the Canadian Hydropower Association estimate of "greater than 5,000 MW" and the Ministry of Natural Resources study of 6,046 MW. However, of this capacity range only approximately 1,000 MW are available for small, low-impact hydropower development and refurbishments. It must be emphasized that the International Energy Agency resource estimate is based on small hydro sites, and provides a resource level of 2,193 MW. The range of these estimates indicates the need for a more detailed provincial assessment to clarify the potential for low-impact hydropower development.

## 2.6 ONTARIO'S ACHIEVABLE POTENTIAL

One of the few existing sources to estimate the timelines involved in implementing provincial hydroelectric development is Ontario Hydro's 1990 Demand Supply Plan.[26] The Ontario Hydro plan comprised 18 sites, which included nine new sites, three redevelopments and six extensions totaling 2,935 MW of installed capacity. The plan called for development to bring on new capacity in 2000 and complete the program implementation in 2016.

Using Ontario's Hydro's hydroelectric plan as a benchmark and project timeline of what could be achieved in Ontario if significant provincial impetus is placed on hydroelectric development, it is possible to construct a very conservative estimate of what can be achieved between 2004 and 2020.

Under favourable governmental and contractual conditions, it is reasonable to assume that non-utility generators could develop, upgrade or refurbish at least 1,000 MW of existing or new small-hydro capacity over the same study period.

### 2.7 ECONOMIES OF SCALE FOR HYDROPOWER

The dynamics of economies of scale are not nearly as favourable for hydro development projects as compared to other renewable technologies. For example, development of multi-unit wind farms benefit from advantages in economy of scale by amortizing first time design, environmental assessment, engineering and infrastructure costs. Although multi-unit hydroelectric cascade systems may offer some economies of scale, hydropower projects tend to almost always be one-off developments, which do not benefit from the advantages of economies of scale.

**TABLE 2**

Estimated contributions – hydroelectric generation

| Year | Cumulative capacity in-service (MW) (refurbishment & small hydro) |
|---|---|
| 2004 | 0 |
| 2005 | 0 |
| 2006 | 0 |
| 2007 | 71 |
| 2008 | 155 |
| 2009 | 260 |
| **2010 (mid Kyoto)** | **435** |
| 2011 | 522 |
| 2012 | 550 |
| 2013 | 580 |
| 2014 | 591 |
| 2015 | 649 |
| 2016 | 798 |
| 2017 | 853 |
| 2018 | 889 |
| 2019 | 946 |
| 2020 | 1,000 |

Note.
Table 2 does not include the Niagara Tunnel project. The timeline assumes environmental and regulatory assessments completed to allow first projects on line by December 31, 2007.

## 3. Policies, mechanisms, and incentives to enhance the viability of Ontario's hydroelectric power

A key first step to ensure that hydroelectric development occurs in an environmentally-sound, cost-effective, and sustained manner in Ontario, is that a collaborative study of all provincial hydro development sites be undertaken by government and industry to identify resources using a common methodology suitable to all industry developers. Since accessibility plays a crucial factor in the economic profile of remote sites, elements such as roads and grid extensions need to be considered as part of the analysis.

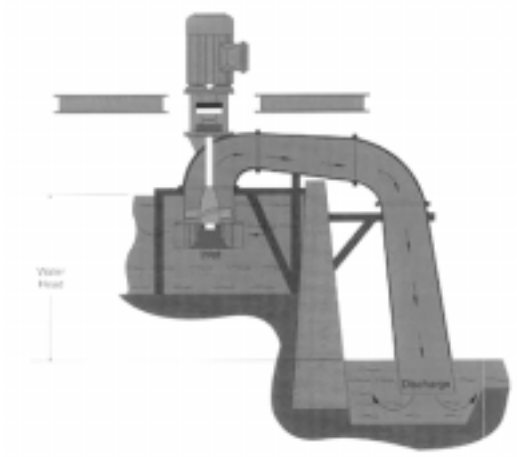


FIGURE 4 Existing flood and flow control dams dot the provincial countryside without providing any of the benefits of hydroelectric generation. Low-cost, siphon-operated turbines may be installed with a minimum of infrastructure or visual degradation at the site. Units such as the model depicted above are perfectly suited for owner-operated systems located on farms and other rural properties where electrical distribution is within proximity. (Courtesy Mavel Industries)

The proposed assessment should also determine if existing flood control or other non-hydroelectric generating dams already present in the province could be upgraded to allow electrical generation.

Connecting smaller renewable generators to the distribution grid does not result in significant impacts and instead can improve the reliability of the province's electricity system. However, the process regulating connections requires province-wide harmonization and studies regarding simplified protection and interconnection standards.

Cost and access to the electrical transmission and distribution systems are major potential impediments to all renewable energy technologies including hydroelectric developments. The existing generator-pay approach to new transmission facilities represents a significant barrier that can curtail hydroelectric development. It is recommended that a portion of transmission revenues be applied to upgraded transmission facilities to help renewable energy resources meet supply objectives.

Another key step to ensure that renewable sources are

developed to their full potential is to implement a provincial strategy to ensure that existing facilities with hydroelectric storage can be used to increase the benefits from both wind and hydroelectric generation.

The new Ontario Power Authority should commission the Ontario Energy Board and the new Independent Electricity System Operator to evaluate the integration of varying amounts of intermittent renewables with Ontario's hydroelectric system to determine how best to coordinate operation among these renewable resources.

A critical factor for the successful implementation of new and upgraded low-impact hydro is the establishment of clear directives within all levels of government confirming renewable energy as "core business."

The implementation of a Renewable Energy Bureau, with a mandate to foster clean energy initiatives and practical mechanisms to ensure that these programs are confirmed within all ministries, is essential to ensure that all forms of renewable energy development, including hydropower, are sustained in the province.

Renewable energy mechanisms (REM) are a useful tool that can be tailored by the province to enable local communities, First Nations, cooperatives, and commercial hydroelectric developers to develop hydroelectric projects.

The fixed-price contracts under renewable mechanisms can be specifically designed to stimulate specific types of hydroelectric developments, which may offer multiple benefits for local communities and the province (e.g. low-impact electricity production, employment creation, community economic development, enhanced local supply security). Furthermore, renewable mechanisms can be designed to ensure that a wide diversity of hydroelectric initiatives are developed, and that the mechanisms act as an incentive to refurbish or develop remote sites.

## 4. Conclusions and further research

Hydroelectric facilities have an historic tradition of powering provincial development, and today continue to provide a low-cost source of electricity that satisfies more than a quarter of Ontario's electricity needs.

The analysis presented here indicates that an additional 1,000 MW of small, low-impact hydro and refurbishments could be available in Ontario (not including the Niagara Tunnel project).[27] These figures are considered preliminary estimates that need to be clarified by a detailed collaborative research study that should be conducted as soon as possible by the province and the hydropower industry.[28]

REMs can be used as a tailored tool to ensure that the most socially and environmentally-desirable hydroelectric projects are developed in Ontario.

Hydroelectricity can play a crucial synergistic role to facilitate the expansion of intermittent renewable resources such as wind in Ontario. Studies and operating experience from utilities in the U.S. indicate that the amount of reserve capacity required to integrate an incremental 1,000 MW of wind generation can be as little as 100 MW (or 10% of renewable nameplate capacity).

## SMALL HYDRO PROJECT IN QUEBEC A FAMILY AFFAIR

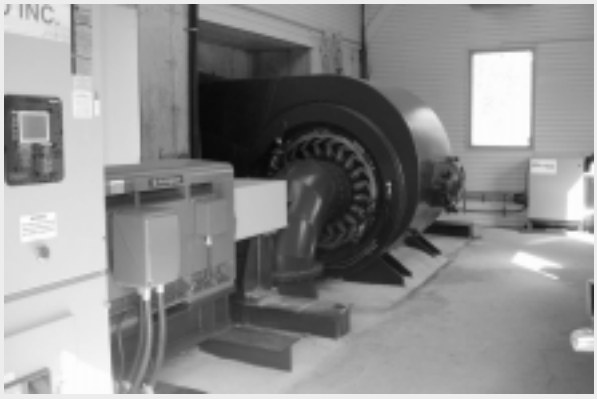
The Blanche River in Gatineau, Quebec, is a pristine location for canoeing and fishing, as well as generating hydroelectricity.

On the river's edge sits a small hydro station owned by father and son Guy and Stephane Laplante. The station is located on an abandoned Hydro Quebec generating site and has been carefully designed to blend with the surroundings and minimize the impact on the natural environment.

The small hydro generating facility delivers energy (0.5 megawatts) to the Hydro Quebec electrical grid under a 20-year purchase agreement.

A 1981 fire destroyed the previous facility owned by Hydro Quebec. Guy Laplante approached Hydro Quebec and purchased the site in 1991. The site was commissioned for operation in the winter of 1998. By keeping their capital and operating costs to a minimum, the Laplantes expect an average return on investment of between eight and 10 percent.

A double-wheel Francis turbine receives water from the head intake structure, which is located above and behind the building. Water flows through a buried supply pipe prior to entering the turbine, whereupon it strikes the "runner blade" assembly. Water pressure imparts a torque on the runner blade, causing the drive shaft to turn. The rotating drive shaft in turn causes the generator's rotor to spin, developing electricity for transmission to the electrical grid.



## HYDRO POWERS FIRST NATIONS COMMUNITY

A small hydro station in northern Ontario is doing a lot more than just generating electricity. It's helping local First Nations build a thriving community.

The Pic River First Nation, a small Ojibway community located between Thunder Bay and Sault Ste. Marie, has part ownership in two hydro stations. By selling power from the hydro stations to the Ontario grid, the band has generated more than $1 million in profits.

Income from the hydro station has helped the band finance a women's crisis centre, a youth centre, a recreation centre, cable television, and high-speed Internet services.

Pic River First Nation first became involved in small hydro development when Chief Roy Michano was invited to sit on a review committee for a proposed hydro development located on Black River, five kilometres east of the community. The Ontario government had identified the site as one with potential for small hydro and was entertaining proposals for development. Rather than take a passive role on the review committee, Chief Michano opted for a more assertive role, choosing to bid for the right to develop the station.

The decision to involve the community in hydro development was based on the band's desire to benefit from this significant economic opportunity. As well, generating power from small-hydro was a good match with the First Nation's view on environmental stewardship.

The Black River generating station opened in 1992. It is a 13.5-megawatt run-of-the-river design, which minimizes the impact on the environment. The power is sold back to Ontario Hydro through a fixed-price, 50-year contract at 6.3 cents per kilowatt-hour.

Experience gained with the Black River hydro development has allowed the First Nations community to gradually build capacity and play an increasing role in the development and management of subsequent hydro ventures. The First Nation has rolled their experience into two other significant run-of-the-river hydro stations.

The Twin Falls Generating Station, a 5.0-megawatt station located on the Kagiano River, and the Umbata Falls Hydro Project, a 23-megawatt station located on the White River are the First Nation's most recent developments.

## HYDROELECTRIC CHAPTER NOTES

1 For a detailed overview of the significant problems associated with large-scale hydro developments see www.irn.org/programs/greenhouse/

2 For more details see the electricity generation section of www.environmentalchoice.ca

3 See Ontario Waterpower Association website www.owa.ca

4 Ontario Power Generation website see Operations/ Hydroelectric Generation www.opg.com

5 Source of world production of electricity estimate: International Energy Agency www.iea.org/Textbase/stats/electricityresult.asp

6 For country specific information see www.small-hydro.com

7 Personal telephone interview with Mr. R. Keating, President of Canadian Hydro Developers (May 14, 2004).

8 Information derived from Ontario Waterpower Association, "Responsible Industry Facts" www.owa.ca and from surveys of member hydropower developers.

9 Ibid.

10 For more details see the International Small Hydro Atlas at www.small-hydro.com

11 Krau, S., Lafrance, G., Saulnier, B., Cohen, J. (2003). *Integrating the Energy Markets in North America: Conditions Helping Large-scale Integration of Wind Power?* In proceedings of 23rd Annual North American Conference of AMEE/USAEE/IAEE, Mexico City, Mexico. http://www.iaee.org/documents/NUIAEEMexico_v2.pdf

12 William, C., Saulnier, B. and Cohen, J. (2002). *Assessment of the impact of wind power penetration on the Vermont electricity grid, Technical Reference 1 of 3.* Montreal: Hydro Québec, Institut de Recherche.

13 Ibid.

14 Hirst, E. (2002). Integrating Wind Energy with the BPA Power System: Preliminary Study. Power Portland: Business Line, Bonneville Power Administration. Available at www.ehirst.com/PDF/BPAWindIntegration.pdf

15 For more details see on BPA's wind integration services see www.bpa.gov/Power/PGC/Wind/wind.shtml

16 For example see the comprehensive report "Dams and Development: A New Framework for Decision Making" authored by the World Commission on Dams available at www.dams.org

17 Low-voltage systems are by comparison very inexpensive, adding approximately $50,000 per km compared to an order of magnitude (or more) for a high-voltage transmission line.

18 We use a conservative estimate because it is expected that potential employment gains will be limited by the fact that some of the additional capacity will be achieved through upgrading existing facilities. Additionally, new sites have a high level of automation, allowing automatic and remote control from existing monitoring facilities, further reducing new labour requirements.

19 See page 52 of Canadian Hydropower association. (2003). Current and planned hydro development in Canada. *Hydropower & Dams*, issue two, 50–52. Available at www.canhydropower.org/hydro_e/p_news_2.htm

20 See Table 2 in Appendix 2 (New Wind Power and Waterpower Potential) of Boileau, D., Estill, G., Norris, P. (2002). Generating Investment in Ontario: Final Report of the Renewable Energy Task Team. Available at www.canwea.ca/downloads/en/PDFS/Investing_in_Ontario_Final_dec_11_2002.pdf

21 Ministry of Natural Resources Waterpower Site Inventory (Excel Spreadsheet) www.owa.ca/policy.html International Energy Agency, Small Hydro Database www.smallhydro.com

22 See Ministry of Natural Resources Waterpower Site Inventory (Excel Spreadsheet) www.owa.ca/policy.html

23 Ontario Hydro. (1990). Providing the Balance of Power: Ontario Hydro's Plan to Serve Customers' Electricity Needs: Demand/Supply Plan Report. Toronto: Ontario Hydro

24 See Ontario Waterpower Association website section "Responsible Industry" at www.owa.ca

25 See Canadian Press article by Livingston, G. (2004). Ontario must build more electricity capacity to deal with shortfall, IMO says. Available at www.greatlakesdirectory.org/on/040104_great_lakes.htm

26 Ontario Hydro op.cit. note 31 see Chapter 12, The Hydraulic Plan.

27 According to the Ministry of Energy, the Niagara Tunnel project "will increase the amount of water flowing to existing turbines at the Sir Adam Beck Generating Station to produce an additional 1.6 terawatt-hours of clean, renewable electricity per year – enough power to meet the annual needs of 160,000 homes, or a city twice the size of Niagara Falls." See Ministry of Energy press release (June 25, 2004): "McGuinty Government Gives Green Light to Expand Electricity Generation at Niagara Falls" available at www.energy.gov.on.ca/index.cfm?fuseaction=english.news

28 It is worth noting that research conducted in 2002 by Boileau et al. (2002) concluded that about 1200 to 2000 MW of hydroelectric capacity is available in Ontario from known new development sites, re-developments at existing facilities, upgrades (re-powering and efficiency improvements) and additional new development. See Boileau, D., Estill, G., Norris, P. (2002). Generating Investment in Ontario: Final Report of the Renewable Energy Task Team. Available at www.canwea.ca/downloads/en/PDFS/Investing_in_Ontario_Final_dec_11_2002.pdf Although the figures quoted on Boileau et al. (2002) are in the same order of magnitude of those provided in this report the key point remains that there is significant variability in all the available estimates of Ontario's hydroelectric potential. A detailed collaborative study is required to clarify the potential and to provide a timeline and guidelines for implementation.

# 4 Biomass in Ontario

## Summary

**Biomass is a renewable source** of energy that has the potential for significant expansion. Ontario can join a number of progressive industrial nations in Europe that have chosen biomass as a major part of their sustainable energy strategy.

Defined as any organic matter of vegetable or animal origin, biomass provides energy to Ontario today in the form of wood chips, pellets, firewood, and landfill gas. New forms of environmentally-friendly biomass sources are also being developed including high-yielding energy crops, crop residues, and biogas.

While there are some forms of biomass that can have significant negative environmental and health implications stringent standards can ensure a truly sustainable use of this renewable resource.

The biggest advantages of biomass sources are that they can be stored and used when needed, and can be used for a multiplicity of applications including heat, electricity or liquid fuel. Biomass can provide a constant, non-fluctuating supply of energy.

A total energy resource of 288 PJ of biomass can be developed in Ontario.

Between 2010–2020, biomass could supply 53 PJ (or 14.7 TWh) of power generation and 169 PJ for heat applications. This amount of biomass power generation is equivalent to an installed capacity of 2,450 MW. If supportive policies are implemented by 2007 biomass could be supplying 9.1 PJ (2.5 TWh) of electricity, which corresponds with a generating capacity of 426 MW.

Our analysis indicates that Ontario could use biomass for heat related energy applications, displacing the use of heating oil, natural gas, propane and electricity. It is becoming increasingly uneconomical to use high-grade forms of energy for this application. A total of 160 PJ of new bioenergy resources could be developed in Ontario with 130 PJ of energy from the agricultural sector (mainly from energy crops), 20 PJ of forest sector residue and 10 PJ from the urban waste recovery sector.

Ontario currently uses about 57 PJ of electricity in the residential sector for space and hot water heating. Biomass energy can help displace this load and significantly reduce peak winter loading problems on the electrical grid, and reduce the overall need for power in the province.

As heating oil, natural gas, propane and electricity continue to increase in price; a major biomass heat industry can develop in Ontario without any significant level of subsidies. Research and development support for energy crops and creative financing schemes for the installation of residential stoves and boilers and district heating systems can help this opportunity to be more quickly realized. This is a high priority for developing the biomass sector as it offers a lower cost option than green power incentives. The use of electricity, heating oil and propane in heat-related energy applications could be dramatically reduced in the province. Developing biomass uses will improve Ontario's trade balance, increase employment, support rural development, reduce greenhouse gas emissions, strengthen electricity security, and help in the transition away from coal and nuclear power.

### 1.0 BACKGROUND ON BIOMASS

The term 'biomass' refers to forestry and agricultural products, residues from agriculture (including plant and animal substances), as well as the biodegradable fraction of industrial and municipal waste. Biomass is derived from a large number of products and residues (e.g. straw, sawdust, bark, and manure).

The supply of all biomass types is determined by physical availability, competing uses, and logistical considerations. Biomass conversion systems have been developed to process a variety of biomass types (e.g. combustion of straw, gasification of wood, and anaerobic digestion of manure) and are at different levels of technological maturity. All biomass technologies have their own specific technical and economic characteristics, which are further described in section 2.

The demand for biomass is primarily determined by the demand for heat, electricity, and transport fuels and the costs and convenience associated with competing energy forms that are also meeting this demand. However, environmental and public health considerations and the reliability of the energy supply also play a key role in determining the suitability of biomass sources as replacements for fossil fuels and nuclear energy.

Therefore, the analysis of biomass sources in this chapter also includes discussions on emissions, biodiversity, soil quality, competing uses, and the energy requirements to process biomass into economical and convenient energy forms for consumers.

The forestry sector generates by-products that can be readily converted to energy with presently-available technologies. Most of Ontario's forest sector biomass is a product of the industrial utilization of sawlogs and is already being recovered for energy. However there is some potential for expanded use of bark and sawdust. There is also a need for energy efficiency projects to enable greater energy recovery from the biomass being utilized by the forest products industry. Some bioenergy advocates are also interested in significantly expanding the use of forest thinnings and recovering more biomass from the forest floor during harvest operations. It should be recognized however that forest productivity is fundamentally dependent on adequate amounts of residual biomass left during harvesting operations to maintain forest nutrient and carbon cycling processes and to prevent soil erosion. Another strategy to expand the impact of forest biomass is to install more efficient combustion appliances in households and commercial buildings. The technology for burning woody biomass (including sawdust, pellets, wood chips and logs) has matured significantly. Consumers can now benefit from technological advances in equipment to provide them with more economical, reliable, convenient and clean burning energy sources from the forest sector.

The resource potential in Ontario for expanding the biomass energy industry from agriculture is large. Growing dedicated energy crops, such as switchgrass and reed canarygrass to produce energy could be a major new industry for Ontario's agricultural sector that could help control rising energy costs in rural areas. Perennial grasses act as solar energy capturing feedstocks, and are more efficient and more environmentally benign than the production of annual grains and oilseeds, which require tillage and moderate to high levels of fossil fuel-based energy inputs. The agricultural sector also generates products such as straw and stalks that could be used for energy purposes. However, these crop residues also play

**TABLE 1**

Sources of Biomass and their potential energy products

| Supply sector | Type | Examples | Energy product [a] |
|---|---|---|---|
| Forestry | Forestry by-products & wood industry | Fuelwood, sawdust, bark, black liquor from pulping operations | H, P, CHP |
| Agriculture | Lignocellulosic agricultural residues | Straw, stalks, and milling residues from corn and oat processing | H, CHP |
| | Lignocellulosic energy crops | Switchgrass, reed canarygrass, short rotation forestry | H, CHP |
| | Livestock manure | Liquid swine and dairy manure | H, P, CHP |
| | Oilseeds and starch energy crops | Corn, winter wheat, barley, oats, canola and soybeans | H, T |
| Urban organic wastes | Residues from food industry | Shells, husks, pulp, used frying oil | H, P, CHP, T |
| | Waste wood | Construction wood, demolition wood | H, P, CHP |
| | Biodegradable municipal waste | Kitchen and garden waste (KGW), organic municipal waste | H, P, CHP |
| | Biodegradable landfill waste | Landfill gas | P |
| | Sewage sludge | Sewage gas | H, P, CHP |

Note
a H= heat, P=power (electricity), CHP= combined heat & power, T= transport fuel (biodiesel, ethanol)

an important role in maintaining soil fertility and preventing soil erosion on farmlands, and they also have other commercial uses. From a technical point of view of use, biomass derived from agricultural sources has historically proven more complex to use than wood residues, which has delayed development of this sector. Agricultural biomass sources generally have higher ash content, and higher potassium and chlorine contents. These features add difficulty in the combustion process due to the formation of clinkers (i.e. incombustible residues) in boilers, causing complications in their operation, and resulting in increased maintenance requirements. However, a growing number of companies have assessed these inherent quality problems with agricultural biomass and bark, and are now introducing efficient combustion technology into the marketplace for these feedstocks. Several Canadian manufacturers are producing sophisticated new stoves that can effectively burn switchgrass, crop residue and bark pellets as well as corn and cereal grains.

Ontario is also a major livestock producing province and the utilization of manure in Ontario for energy could help other environmental needs. Manure use in biogas systems reduces methane emissions and odours, and helps protect drinking water quality.

Biomass resources can also be recovered from consumers, municipalities and industries that are largely located in urban areas. This includes waste wood leftover from construction and demolition projects, and urban organic wastes that are potentially recoverable from households. The food industry also generates residues from several agricultural products that can be considered for energy use (e.g. waste vegetable oil). Landfill gas systems can also significantly reduce the emission of methane, a harmful greenhouse gas, and enable electricity production.

Greater awareness needs to be developed among Ontario consumers in the area of relative efficiencies of the various bioenergy transformation pathways for converting biomass into useful and economical energy forms that can most effectively displace fossil fuels. In Ontario at present, heat and electricity are the main uses for biomass energy. Biomass can also be used for the production of transport fuels such as ethanol and biodiesel. However, conversion of biomass into liquid fuels for transportation appears limited in Ontario from both an economic and environmental standpoint.

The production of annual grains and oilseeds for conversion into liquid fuels is generally an inefficient way to utilize farmland to capture soil radiation compared to other energy farming options. Conversion of these commodities into liquid fuels causes significant loss of the original energy from the feedstock. In the case of biomass conversion into ethanol, significant inputs of fossil fuels are required, which results in a modest net energy gain that is finally captured in the corn field. Much more effective fossil fuel substitution can be made when annual grain crops (or oilseeds) are directly combusted to displace heating oil and natural gas. It is increasingly recognized that conversion of annual grains and oilseeds to liquid fuels is the least desirable energy transformation pathway and requires significant subsidization by the taxpayer to create an industry. For example, in using Ontario farmland to produce energy, the net energy gain from a corn field to ethanol fuel cycle (21.4 GJ/ha) represents only a seventh of the net energy gain in the switchgrass field to pellet heat fuel cycle (163.1 GJ/ha).[1] Both the ethanol and pellets are energy carriers that can be used to displace oil on a near equivalent energy substitution basis.

Cellulosic ethanol derived from crop residues has much more potential as an environmentally-friendly energy conversion pathway for bio-fuel production. However, Ontario has higher costs associated with the production of this biomass than Canada's western provinces or tropical countries such as Brazil because of higher land costs. The ease of transport of an energy-dense commodity such as ethanol provides only a limited opportunity for Ontario to have any comparative advantage in developing this industry.

In Ontario, there are greater opportunities to use farmland to produce heat and power from biomass, which is addressed below in more detail.

## 1.1 WORLDWIDE BIOMASS DEVELOPMENT

Two of the leading biomass-consuming countries in the industrialized world are Finland and Sweden. Biomass supplied 19.4% of Finland's total primary energy supply and 7.9% of its fuel mix in district heating. In Sweden, biomass accounted for 15% of total primary energy supply and 53% of the fuel mix in district heating.[2] A key lesson from Finland and Sweden has been the usefulness of strong and stable incentives to develop their biomass markets.[3]

For modern biomass technologies to become a sustainable energy generation strategy, several environmental considerations need to be addressed. For example,

if agricultural and forestry residues are being considered for energy purposes, existing uses of these resources need to be evaluated to avoid compromising ecological cycles. Large monoculture plantations for energy crops should be avoided in favour of planting a variety of species in the landscape as monocultures decrease biodiversity and increase vulnerability to pests and diseases. When considering species selection for energy crops and plantations, it is important to favour moderate to high-yielding plants that require low-inputs of fossil fuel-derived energy inputs and pesticides, as well as low to moderate water requirements. The land base for sustainable bioenergy production from energy grasses and trees should mainly be comprised of marginal lands to ensure that competition with food production is not compromised.[4] As well, there is a need to ensure that clean combustion technologies are introduced into the marketplace. Biomass combustion can be a significant source of air pollution and a health concern in densely populated areas. More communities are looking at controlling the use of fuelwood-burning household appliances to help reduce the particulate load that deteriorates ambient air quality. District heating systems and pellet burning appliances can greatly reduce poor air quality incidents associated with fuelwood burning for heating using wood stoves.

An emerging international strategy that is showing promise is the development of densified biomass for heat and power production. The main advantages of densified fuel pellets, cubes, and briquettes include ease of handling, transport and improved combustion efficiencies due to better control over the combustion process.

Canada is now exporting more than 100,000 tonnes of pellets made from sawdust and other wood processing residues into Northern Europe.[5] The global trade in solid and liquid biofuels will see new trading markets emerge for biofuels and for equipment and technology to develop this new industry. The economics of Ontario's emerging bioenergy industry will undoubtedly be affected in the future by external factors such as the importation of ethanol or foreign-made biomass boilers.

## 2. Biomass is growing as a competitive energy source in Ontario

The use of biomass is becoming an increasingly attractive heating option, particularly as it can displace expensive high-grade energy forms like propane, heating oil, electricity or natural gas. As these commodities rise in price, interest in biomass energies will continue to increase. The advancement of technologies is also helping develop the biomass industry as equipment becomes more efficient and convenient to use. The forest products industry has also identified biomass as a strategic opportunity to control their energy costs as fossil fuel prices rise, and to meet their greenhouse gas mitigation requirements under the Kyoto protocol.[6]

### 2.1 TECHNOLOGY CONSIDERATIONS

There are various technologies to convert biomass into heat, electricity and combined heat and power. Combustion is the most common approach. Biomass combustion systems range, in order of capacity, from domestic heating to district heating and from electricity generation to co-generation with existing power plants. There are significant opportunities of expanding the use of biomass in residential, commercial and industrial applications.

### 2.2 COMBUSTION APPLICATIONS FOR HEAT

Biomass has a long history of use for heating Ontario homes. While many rural citizens continue to use locally-available firewood to provide their winter heat, the majority of consumers have switched to more convenient heating systems such as natural gas, oil and electricity. Biomass provides approximately 5.5% of the space heating in Ontario. No significant hot water heating is done by biomass in the residential sector (see Table 2 in Ontario Energy Appendix).

The market is increasingly dominated by natural gas with modest declines in electricity use and significant declines in heating oil in the past 10 years. The residential heat energy industry represents an enormous energy market for biofuel products. Based on 2002 consumption levels and the cost of sourcing fuels from Figure 1, the annual expenditure by consumers on heating (not including capital costs of equipment) are estimated at $5.55 billion CDN annually in Ontario. The breakdown of the main expenditures is $3.43 billion on natural gas, $1.58 billion on electricity, and $457 million on heating oil.

One important new strategy to increase the convenience and accessibility of biomass heating fuels is densification of biomass material. Biomass is bulky, and both the forest and farm are often quite distant from energy consumers. There are many advantages to densified fuel pellets:

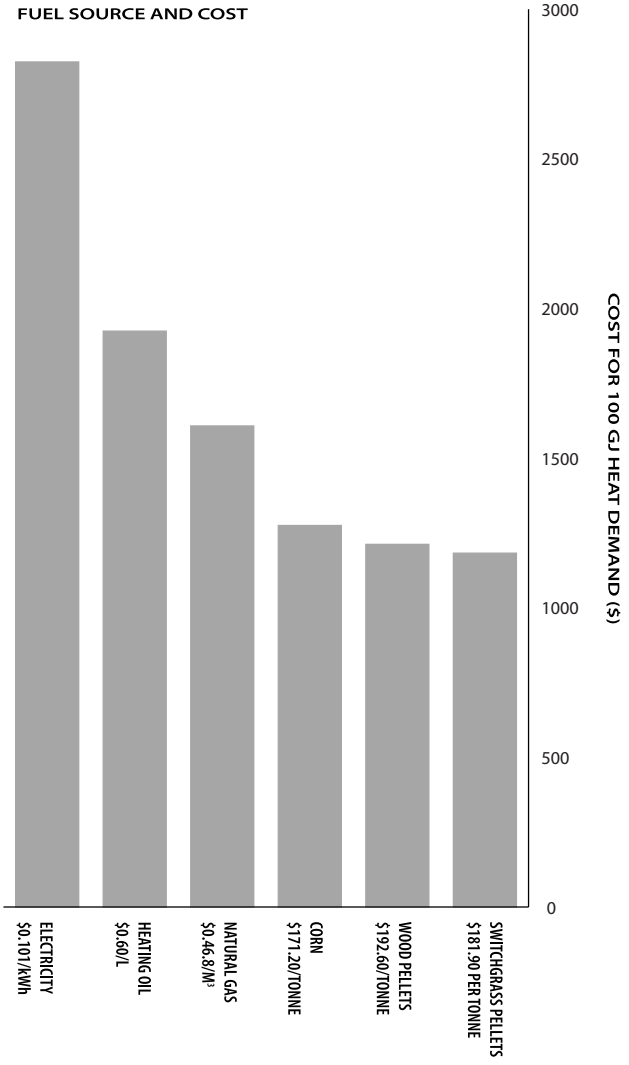



FIGURE 1 Estimated annual fuel costs for residential heating options in Ontario.
Note:
Assumptions: energy values and conversion efficiencies of electricity 0.0036GJ/ kWh and 100%, heating oil, 0.0387 GJ/l and 82%, natural gas 0.03723 $m^3$ and 85%, corn 15.8 GJ/tonne and 85%, wood pellets 18.7 GJ/tonne and 85%, switchgrass pellets 18.1 and 85%. Fossil fuel energy prices from Ontario Ministry of Energy (http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13) and www.energyshop.com. Natural gas also has an annual delivery charge of $120/yr/household.

- The amount of dust and waste produced is minimized
- The fuel is free-flowing, which facilitates ease of material handling
- The energy density is increased, easing storage and reducing transportation costs
- Uniformity of size and control of flow permits more efficient combustion control

Home heating with "pellet boiler systems" is popular with consumers in Sweden, Austria and Germany. These systems operate like conventional central heating systems and are completely automatic. The boilers are fed wood pellets made mainly of sawdust, shavings, and other leftovers obtained after processing trees for lumber and other wood products. At a pellet mill, the material is dried, compressed, and formed into pellets. In British Columbia, an association of pellet fuel manufacturers is active in producing pellets for the North American and European markets. An estimated 10,000 Ontario homes now have pellet stoves.[7] Pellet boilers are just beginning to be marketed in the province. The annual savings for switchgrass pellet heating systems vs. electrical, oil, and natural gas heating are 58%, 36%, and 16%, respectively.

Another way of making biomass heating more convenient to energy consumers is through the use of district heating systems, where hundreds of homes can be provided with heat in the form of hot water distributed through underground pipelines. In northern Europe and China, district heating is widely being used to improve convenience for consumers and to save energy and costs compared to the installation of individual boilers for households. There is significant potential for the development of biomass district heating systems and pellet boilers and stoves in Ontario.

The development of 160 PJ of new energy from the biomass sector could have significant impact on the residential sector by helping address Ontario's power problems. The residential sector consumes about 32% of Ontario's electricity supply with 55.9 PJ being used for space and hot water heating.[8] Peak winter loading problems are mainly caused by the residential heating sector. With 160 PJ of new biomass energy available in Ontario, the province could halve its use of electricity in space and hot water heating applications in households using biofuels. This savings of 28 PJ of electrical energy could be achieved with 37 PJ (assuming a conversion efficiency of 75% in a district heating system and pellet boilers and stoves) of the 160 PJ biomass resource. In a different scenario, where the status quo of electrical heating in Ontario is maintained at current levels and biopower is used to replace coal in power generation, 93 PJ of biomass would be required to replace the 28 PJ of electricity (assuming a 30% conversion efficiency). Use of biomass for heating in the residential sector to displace electrical heating is a strategic opportunity for the province to encourage.[9]

## 2.3 ELECTRICITY FROM BIOMASS

Generating electricity with solid biomass typically takes place with the help of a steam generation system. Steam

systems are generally too expensive for very small-scale applications, and most district systems are therefore heat-only systems.

Compared to large electricity plants, which have an electric efficiency of 30–40%, combined heat and power systems (CHP) have a low electric efficiency of 20–30%. However, CHP systems can produce both electricity and heat, which results in a total efficiency of 60–90%. An important characteristic of CHP plants is that they have to be located near the consumer of heat, which is often a district heating network or a factory using process heat.[10]

Biomass integrated gasification/combined cycle (BIGCC) systems combine flexible fuel characteristics and high electrical efficiency. Electrical conversion efficiencies of 40–55% are possible at a scale of about 30 MW. Demonstration projects are under way in several countries and for various gasification concepts.[11]

## 2.4 ANAEROBIC DIGESTION

Another way to produce gas for power is through anaerobic digestion. This process is the biological degradation of organic material in the absence of oxygen.[12] This process results in the production of biogas, a valuable (energy containing) product. Biogas is a mixture of several gases and vapors, mainly methane and carbon dioxide. Methane also is the main component in natural gas and contains the bulk energy value of biogas. Biogas is a reasonably clean fuel, which can be used in a gas engine or turbine to generate electricity.[13]

Anaerobic digestion of manure for electricity generation is currently applied on a large scale in Germany where about 1,500 farm-scale digesters have been installed.[14] The electricity generated is sold to the grid, and the heat is used for farm and barn heating. The digested manure can then be used as fertilizer on farmland, as with manure that is not digested. Research in Denmark and the Netherlands shows that digested manure has equal or better fertilizing potential than ordinary manure.

Manure digestion for electricity generation is successful in Germany because of the implementation of renewable energy mechanisms targeted for this application, making the country a world leader on this technology.[15]

The same anaerobic digestion process that produces biogas in animal manure and wastewater treatment digesters occurs naturally underground in landfills. Most landfill gas results from the decomposition of cellulose contained in municipal and industrial solid waste. Unlike animal-controlled anaerobic digestion with manure, the digestion occurring in landfills is an uncontrolled process of biomass decay. The result is that landfills emit methane into the atmosphere (a harmful greenhouse gas with 21 times the heat trapping ability of carbon dioxide). To avoid this problem, the European Union has taken the initiative to make landfill gas capture mandatory (as Ontario also has done for new landfills). In many situations, the collection of landfill gas and its conversion to electricity-using gas engines is profitable, and such systems are becoming more widespread.[16]

## 2.5 ECONOMICS OF POWER GENERATION FROM BIOMASS

A recent overview of estimated costs for electricity generation using biomass in Canada concluded that biomass co-combustion (i.e. burning biomass with coal) costs about 7¢ per kWh, landfill gas 6–7¢ per kWh, and biomass combustion 5.5–11¢ per kWh.[17]

However, a more detailed analysis of these costs reveals that landfill gas and co-combustion costs are closer to 4.5¢ and 6¢ per kWh respectively. Other options such as large combined heat and power (CHP) are more expensive and cost about 11¢ per kWh, and farm-based anaerobic digestion systems, which are generally applied at a relatively smaller scale, cost about 17¢ per kWh (for details see Biomass Appendix). Although the costs of anaerobic digestion are currently higher than other biomass technologies, it represents an option that can be relatively easy to implement because of its small scale, the current availability of manure, and the demand for heat at the farm level.

## 2.6 BENEFITS OF BIOMASS

If broad environmental considerations and guidelines are implemented, biomass can become a reliable source of heat and electricity generation in Ontario. Biomass can also help cut the province's greenhouse gas emissions as it can displace fossil fuels such as oil and coal. Furthermore, electricity generation from landfill gas is an effective strategy to minimize methane emissions from municipal solid waste. Development of biomass sources can also lead to significant job creation and contribute to rural development.

## 2.7 EMPLOYMENT

Employment figures from Germany indicate that more than 50,000 people are employed in the biomass sector

(by comparison about 40,000 are employed in Germany's powerful wind industry).[18]

Recent employment estimates suggest that biomass projects require a range of 10–42 personnel per each 100 GWh/year (i.e. 10 staff if biomass is collected from forestry residues, 36 staff if biomass originates from agricultural wastes, and 42 if biomass is obtained from energy crops).[19] Extrapolation of these employment figures to Ontario indicate that by 2007 between 250 to 1,050 persons could be employed in the biomass power sector, and that by 2020 biomass employment could range from 1,470 to 6,174 jobs (these estimates refer only to potential employment related to biomass electricity generation).[20]

Although these estimates provide only a crude initial estimate of the potential employment benefits, it is clear that the potential economic gains especially for rural areas are quite tremendous. Nevertheless, more detailed, context-specific, analysis is needed to determine the actual employment potential of increasing biomass use in Ontario for electricity and heat applications.

### 2.8 RURAL DEVELOPMENT

Biomass resources can be especially appealing to Ontario's farmers, who are currently facing significant economic hardship. Recent estimates by Agriculture and Agri-Food Canada indicate drastic decreases in Ontario's farm income due to the compounding detrimental effects stemming from loss of U.S. markets and the increase in value of the Canadian dollar.[21]

If environmental safeguards are implemented to ensure that biomass sources are developed and employed in a sustainable way, an expansion of biomass use for energy purposes holds significant potential to provide improved and more stable income levels for farmers and to strengthen local communities. For example, it appears higher farm income receipts could be derived from perennial grasses such as switchgrass than producing beef cattle on marginal farmlands.

As well, manure can be efficiently collected on farms to generate heat and electricity. This strategy can also help minimize the pollution of local water bodies by generating a valuable fertilizer that poses much less risk to human health than liquid manure applications to farmland. Water pollution from untreated manure remains a serious challenge affecting many communities in rural Ontario, a problem that has gained increased attention after the Walkerton tragedy.[22]

## 3. Ontario's biomass resource: A growing diversity of supply

Ontario has a variety of potential biomass resources available from forestry, agricultural, industrial food residues, and waste sources. The next section evaluates the potential of the three main biomass resource sectors in Ontario.

For each type of biomass the total, technical and practical resources available are estimated using the following definitions:

- The total resource is the energy content of the total quantity of biomass that is potentially available, not taking into account environmental, technical and logistical considerations.
- The technical resource is the total resource potentially available, limited by the current technical ability to extract energy from these sources. It is related to the quantity of biomass that could be obtained in an environmentally- sustainable way with help of state-of-the-art technologies. Within a timeframe of 10–20 years it should be possible to develop the resource.
- The practical resource is the technical resource, additionally limited by basic practical incompatibilities such as competing uses of the resource.

### 3.1 FOREST SECTOR BIOMASS

In Ontario, an area of 58 million hectares (ha) is covered with forests, of which 42.2 million ha (73%) is timber productive (class II) forest and 15.8 million ha (27%) is timber non-productive forest.[23] The average biomass density of productive class II forest in Ontario is 87 tonnes/ha. Therefore, in total, about 3.7 billion tonnes of wood biomass is stocked in productive class II forests.[24]

The timber non-productive forests of Ontario consist of open muskeg, treed muskeg, rock, protection forest and brush and alder with varying biomass densities. Using the average stand density of the Boreal shield of 6 tonnes/ha, the total biomass contained in unproductive forest is 95 million tonnes, which is approximately 25% of the biomass stocked in timber productive forests. Moreover, these forests are often reserved and protected from harvesting, as they are extremely slow to regenerate.

### 3.2 TECHNICAL RESOURCE ESTIMATION

Only a small portion of the total stock of wood biomass is available for use on an annual basis as energy. Some

areas are economically unfeasible to harvest and some areas are protected for ecological purposes. The merchantable volume of roundwood harvested on provincial and private lands in Ontario in 2001 is summarized in Table 2.

**TABLE 2**

Net merchantable volume of roundwood harvested on provincial and private lands in Ontario 1999–2002[25]

| Year | Volume (1000 $m^3$) | Mass[a] (ktonnes) | Energy content[b] (PJ) |
|---|---|---|---|
| 1998 | 24,126 | 10,133 | 182 |
| 1999 | 24,814 | 10,422 | 188 |
| 2000 | 28,118 | 11,810 | 213 |
| 2001 | 29,099 | 12,222 | 220 |
| 2002 | 26,319 | 11,054 | 199 |
| **5-year average** | **26,495** | **11,128** | **200** |

Note
a Assuming an average solid dry density of 420 kg/m3
b Assuming a net calorific value of 18 GJ/tonne

Roundwood is defined as sections of tree stem, with or without bark. It includes logs, bolts, pulpwood, posts, pilings, and other products in the subcategory known as industrial roundwood. It also includes fuelwood and firewood, which are harvested in fairly modest volumes. However, the total quantity of harvested biomass is actually higher, as branches, foliage and (part of the) bark are not included in the statistics. The proportion of total biomass to roundwood differs per type of tree and can vary regionally.[26] In this study however, an approximate estimation is made based on the numbers in Figure 2.

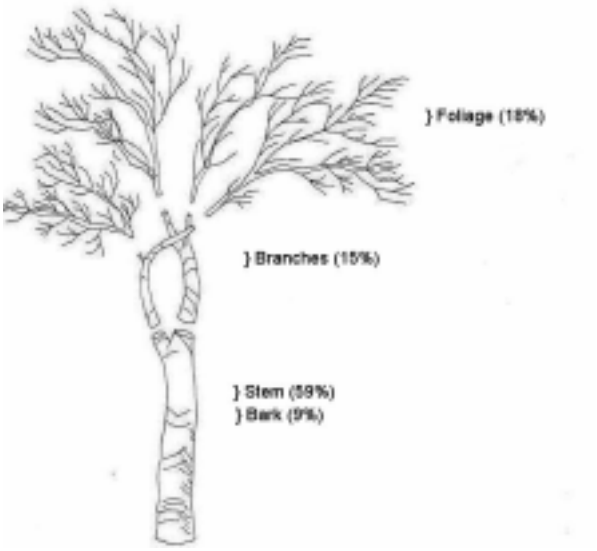



FIGURE 2 Approximate distribution of above stump biomass (% on dry basis)[27]

In sustainably-managed forests, branches and foliage are left in the forest for maintaining the carbon and nutrient cycling process and to provide habitat for the animals in the forest. Clear guidelines for sustainable forestry have been established by the Forest Stewardship Council, which also provides a certification system to ensure that forests are well managed.[28]

Bark is usually removed centrally, and except for local energy generation it is hardly used for other purposes. Most modern wood processing industries use some the energy contained in bark, for on-site energy generation. Special bark combustion systems are developed for this purpose. The technical potential of this resource if it was used exclusively for energy in Ontario is 229 PJ, consisting of roundwood (200 PJ, Table 2) and bark (29 PJ, Table 3).

## 3.3 PRACTICAL RESOURCE ESTIMATION

While the technical resource estimation is based on statistics about the supply of wood, the practical resource consists of residual products from the paper and pulp industry, the timber industry and wood used in households. Stem wood is generally judged to be too expensive for energy purposes because of competition with the higher-value fibre products industries.

### BARK

At the time of harvest, most of the bark is removed together with the harvested stem. All 29 PJ (Table 3) of bark can be regarded as the practical resource. Bark is considered the main new incremental biomass resource from the forest sector that can be developed in Ontario. Some of the bark resource, however, is already utilized internally for energy in the forest products industry.

### BLACK LIQUOR AND WASTE WOOD USE IN THE PULP AND PAPER INDUSTRY

Black liquor refers to the residual aqueous mixture of lignin, organic chemicals and inorganic chemicals recovered after pulping of wood through the Kraft pulping process. In the case of softwood trees, 27–28 % is lignin. The dry solid content of black liquor depends on the evaporator system in the mill, but is typically within the range of 65% to 75%. Its gross and net calorific values are 14.3 and 12.4 GJ/tonne, respectively. In traditional Kraft pulp mills, the black liquor is burned in a chemical recovering boiler, enabling recovery of the inorganic pulping chemicals and conversion of the organic components into thermal energy in the form of

steam.[29] From the viewpoint of sustainability, it is essential to utilize the generated thermal energy in an efficient manner. Natural Resources Canada (NRCan) indicates that the paper and pulp industry uses 83 PJ of energy per year from wood waste and pulping liquor, providing more than 50% of the energy demand in this sector.[30] However, the share between wood waste and pulping liquor is not currently available in NRCan's online database.

### SAWDUST AVAILABILITY FROM THE SOLID WOOD PRODUCTS INDUSTRY

The lumber, panel and veneer manufacturing industries consume the logs and bolts mentioned in Table 3. It is estimated that in the Ontario sawmill industry, 1.53 million tonnes of wood residues are produced, of which 1.08 million tonnes are already used, and 0.45 million tonnes are still unused.[31] Assuming that these residues consist of 50% bark and 50% sawdust, then it is estimated that 0.76 million tonnes of sawdust are produced. This corresponds with a practical resource of 13.7 PJ of sawdust, of which 70% is used and 30% is projected to be unused. The sawdust that is currently utilized is for heat generation applications and is burnt directly or manufactured into wood pellets for commercial sale in Ontario. There are also is significant volumes of wood residues used in the wood processing industry. Shavings are also widely used as bedding in the livestock and poultry industry. The used and unused sawdust are considered part of the practical resource.

### WOOD FUEL FOR RESIDENTIAL USE

NRCan indicates that in 2001 in Ontario, 16.7 PJ of wood was used in the residential sector.[32] Most of this fuel is cut in forests but some is also slabwood from the forest products industry. It should be regarded as part of the practical resource. There could be some potential for increased use of wood fuel from forest thinnings in the future if energy prices and wood prices rise to help support the high labour cost of this activity.

### TOTAL FROM THE FOREST SECTOR

The total practical energy potential from the forestry sector is identified as 142 PJ annually (see Table 3). It is estimated that 20 PJ of this is new incremental energy from the forest sector that is not currently developed, mainly consisting of bark.

## 3.4 AGRICULTURE

The agriculture industry offers major potential for expansion of the bioenergy industry in Ontario. Unlike the forest industry, only limited amounts of biomass have to date been developed. Four types of biomass can be produced from agriculture: grains and oilseeds, energy crops, agricultural residues, and livestock manure. This section will discuss these various biomass options and the overall opportunity to best collect and store solar radiation using crops on Ontario farmland.

**TABLE 3**

Practical resource from the forestry sector[33]

| Resource | PJ |
|---|---|
| Bark | 29 |
| Spent liquor and wood waste | 83 |
| Sawdust | 13.7 |
| Wood fuels for residential use | 16.7 |
| **Total** | **142** |

The use of annual grains and oilseeds for energy has been widely encouraged by commodity groups in Canada as a means to strengthen demand for these commodities and improve prices. In terms of a system to capture and store solar radiation with energy crop farming, Figure 3 compares the relative efficiencies of present-day Ontario field crops with a bioenergy crop planted for energy. The net energy gain is determined by comparing the total energy production (yield x energy content) and subtracting the energy inputs required for crop production. From Figure 3 it can be seen that there is a fundamental advantage to the use of perennial grasses like switchgrass as energy crops. When densified through pressing and used in modern biofuel combustion appliances, switchgrass pellets can be used as the same energy end-use efficiencies as modern heating oil and natural gas heating appliances. From a fossil fuel displacement and greenhouse gas mitigation standpoint, perennial energy crops represent Ontario's best land-use strategy for developing a major biofuel industry.

### ENERGY CROP FARMING

There are 3.6 million ha of Ontario farmland managed for crops and forage production (Table 4). Approximately one-third of Ontario's farmland is in forage crop production for the ruminant livestock industry. It may be economically advantageous for several reasons for Ontario farmers currently involved in the ruminant livestock industry to diversify a significant portion of their forage lands into the production of perennial grasses (such as switchgrass or reed canary grass) for energy production. It would let Ontario farmers take advantage

of the increasing value of biomass in the province. Biomass in Ontario is increasingly scarce as greenhouse operators and other large heat energy users switch away from natural gas and other heating systems. Consumers in Ontario face higher energy costs for natural gas and electricity than provinces in Western Canada and consequently can pay higher prices for biomass fuels. While densified biomass can be transported by rail, it is likely that local production of biomass in Ontario can compete with the costs of importing densified fuels into the province from Western Canada.

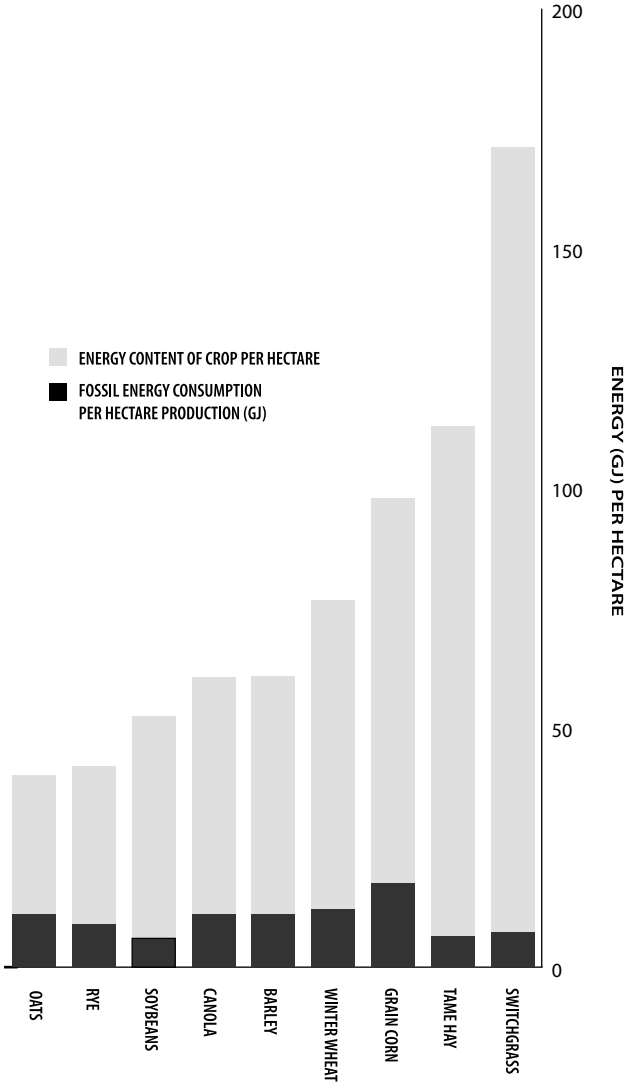



FIGURE 3 Solar Energy collection and fossil fuel energy requirements of Ontario crops, in giga-joules (GJ) per hectare (for sources see Biomass Appendix)

With Ontario having 620,000 ha available for biofuel production and assuming a 9 tonne per hectare yield, a total of 5.58 million tonnes of biomass could be grown annually in the province. Assuming this biomass contains 18.5 GJ/tonne, a total of 103 PJ of energy could be produced. This would be approximately six times the energy production potential of crop residues in the province. This energy production base would result from the conversion of approximately 1/6 of Ontario's total farmland into energy crops. The land base would consist mainly of land currently dedicated to the beef industry and to land under cultivation of grain crops, such as oats and barley, in marginal areas that are bringing relatively low profitability to Ontario farmers. Switchgrass and reed canarygrass would be the main initial scale-up species for southern and northern Ontario respectively. Research in Quebec and in South Dakota has also identified prairie cordgrass as a promising warm season grass bioenergy crop that has higher yield potential than switchgrass and is also better adapted to poorly drained soils and areas with cooler nighttime temperatures.[34] The main advantage of using warm season or C4 grasses is that they convert solar radiation 40% more efficiently than cool season species and they use only half as much water for every tonne of biomass produced. Other potential perennial energy crop species in Ontario include the warm season perennial grass species of big bluestem, indiangrass and miscanthus, and short rotation forestry and windbreak species including willow, poplar, black locust, alder and indigo bush.

It will take time to establish a supporting infrastructure and to develop experience in energy crop production amongst farmers. As a rough estimate, it is

**TABLE 4**

Potential land base available in Ontario for biofuel production from grasses

| Location | Land use categories | Total acreage (millions ha) | Percentage converted to biofuels | Estimated biofuel acreage (millions ha) |
|---|---|---|---|---|
| Ontario | Annual crops | 2.35 | 10% | 0.23 |
| | Hay | 0.93 | 30% | 0.28 |
| | Seeded pasture | 0.35 | 30% | 0.11 |
| | | | **Total** | **0.62** |

assumed that 20% of the required land resource base could be planted within four years, which corresponds to 120,000 ha and 20 PJ of primary energy. After 10 years, the total practical resource of 103 PJ could be achieved. After 2015 there would be an annual expansion of 1–1.5% in the resource base with the ongoing introduction of improved energy crop cultivars and production technologies.

### AGRICULTURAL RESIDUES

Cereal straws and corn stover are the major potential biomass residues as sources for energy generation.[35] The theoretical, technical and practical resources from agricultural residues in Ontario were calculated using a study on available residues on the basis of crop statistics and crop-to-residue ratios.[36]

Not included in this analysis is the potential for crop residue generated from commodity milling. In Ontario, oat hulls and fibres from corn milling can also be considered a small but important additional crop energy resource for utilization, as they are already concentrated and available at an affordable price.

**TABLE 5**

Energy potential of selected field crop residues in Ontario (PJ/year)[a]

| | Total resource (PJ) | Technical resource (PJ) | Practical resource (PJ) |
|---|---|---|---|
| Winter wheat | 21 | 14 | 5 |
| Spring wheat | 3 | 2 | 1 |
| Oats | 1 | 1 | 0 |
| Barley | 8 | 6 | 2 |
| Rye | 1 | 1 | 0 |
| Mixed grains | 5 | 4 | 1 |
| Grain corn | 73 | 36 | 7 |
| **Total** | **113** | **64** | **17** |

Note
a Based on Table 6 and an average lower heating value of 18 GJ/tonne.

The total resource (113 PJ) shows the energy content of all straw that is produced yearly from the relevant agricultural field crops in Ontario (Table 5). It is important to note that a part of these residues must be left on the field to maintain soil quality. Sustainable removal rates depend on many factors, including soil type, slope of the land, soil fertility levels, crop rotation systems, tillage, cutting height, crop yield, weather and wind patterns. Using a removal rate of 60–75% for winter wheat and 70–75% for other cereals, it is estimated that 64 PJ of energy is available.[37] The practical resource (948,000 tonnes or 17 PJ) is estimated by taking into account the alternative uses of the residues (e.g. animal fodder, straw for livestock bedding, mushroom production etc.), and the difficulty in harvesting corn stalks. In addition, the agricultural sector can provide significant amounts of energy from spoiled, mouldy and low quality grains, and from by-products of grain milling (especially corn and oat milling). It is estimated that 275,000 tonnes of grains and grain milling residues, which is 5% of the 5.5 million tonnes of grains produced in Ontario, could be available for bioenergy applications. Assuming this biomass has an average energy content of 18 GJ/tonne, it would provide an additional 5.0 PJ of energy annually to Ontario.

### LIVESTOCK MANURE

The yearly quantity of manure available in Ontario is estimated by using data on animal stock and manure production per animal. Table 7 shows the resulting energy potentials that were estimated on the basis of calculations on manure availability in Ontario as provided in Table 8. The use of liquid manure sources as energy is desirable from an environmental standpoint as this is the major source of methane and odour emissions from Ontario agriculture and a risk to water quality.

The total resource of 45.1 PJ is equivalent to the energy content of the manure (Table 8). Wet manure of pigs and cows is suitable for anaerobic digestion.[38] The technical resource of 18.7 PJ represents the energy that can be gained with anaerobic digestion. Because biodigestion of chicken and turkey manure is more complex, these resources are not considered as part of the practical potential. Poultry litter, commonly containing wood shavings, can be converted to energy through direct combustion for heat. However this energy conversion pathway is not considered viable for Ontario because from an environmental standpoint, combustion of nutrient rich poultry manure in Ontario should be avoided. Combustion of this material can be a significant source of NOx pollution as it generally contains more than 3% nitrogen. This manure is also a relatively rich source of nitrogen and nutrients and can be used as an organic source of nitrogen (N) to displace the use of inorganic N fertilizer forms (such as urea or anhydrous ammonia) in crop production. Most regions in Ontario have a significant cash crop farming land base available for recycling of manure from neighbouring poultry farms.

The availability factor in Table 7 shows how much ma-

**TABLE 6**

Calculation of the availability of agricultural residue in Ontario in 2001

| | Area [a] (x1000 ha) | Product yield[b] (tonnes/ha) | Residue to crop ratio[c] (for theoretical potential) | Total resource[d] (ktonnes) | Share of theoretical potential available for technical resource | Technical[e] resource (ktonnes) | Share of technical resource practical available for potential | Practical resource[f] (ktonnes ) |
|---|---|---|---|---|---|---|---|---|
| Winter wheat | 218.5 | 4.1 | 1.3 | 1165 | 0.68 | 792 | 0.35 | 277 |
| Spring wheat | 46.5 | 2.9 | 1.3 | 175 | 0.72 | 126 | 0.35 | 44 |
| Oats | 28.3 | 2.1 | 1.3 | 77 | 0.72 | 56 | 0.35 | 19 |
| Barley | 109.3 | 3.2 | 1.3 | 455 | 0.72 | 327 | 0.35 | 115 |
| Rye | 24.3 | 2.2 | 1.3 | 69 | 0.72 | 50 | 0.35 | 18 |
| Mixed grains | 68.8 | 3.1 | 1.3 | 277 | 0.72 | 200 | 0.35 | 70 |
| Buckwheat | 1.6 | 1.7 | 1.3 | 4 | 0.72 | 3 | 0.35 | 1 |
| Grain corn | 777 | 5.2 | 1 | 4040 | 0.5 | 2020 | 0.2 | 404 |
| **Total (ktonnes)** | | | | **6263** | | **3574** | | **948** |

Note
a Derived from various information sources stated in Helwig et al. (2002), Agricultural biomass residue inventories and conversion systems for energy production in eastern Canada. 2002, Resource Efficient Agricultural Production (REAP): Ste. Anne de Bellevue, Quebec.
b Data related to 2001.
c Average yield 1997–2001.
d The total resource equal to the total quantity of residues that is released.
e The technical resource takes into account ecological sustainability; for instance a quarter of the cereal straw has to be left on the field.
f In order to estimate the practical resource, the share of straw that is needed for animal fodder and other purposes is deducted from the technical resource.

nure is released centrally that can be collected and used in an efficient way. The resulting practical resource is 4.9 PJ.

## 3.5 WASTE BIOMASS RESOURCES FROM URBAN AREAS

There are five major types of biomass in the waste sector that are predominantly from urban areas and which can be utilized for energy: waste wood, food residues, biodegradable municipal residues, landfill gas and sewage. These will be discussed in the section below.

### FOOD INDUSTRY

In the food industry, considerable quantities of organic materials are produced from a great variety of processes. In the agri-food industry, many vegetable residues are currently valued as animal fodder. Slaughterhouse waste is another potential source of energy. However, public perception is generally negative towards the utilization of such residues. Used frying oil is a vegetable product, which is less problematic from the view of public perception. It forms a source of energy that can be utilized for heat and electricity generation or processed further into biodiesel (methylesters). A recent study estimated that in Ontario, 70 million litres of yellow grease is produced corresponding to an energy potential of 2.3 PJ (Table 9).[39]

Identifying all relevant residues is beyond the scope of the present study; however, it is anticipated that the theoretical and practical resources may exceed 50 and 10 PJ, respectively. The practical resource is currently estimated by the used frying oil, which has an energy value of 2.3 PJ.

**TABLE 7**

Energy potential of livestock manure in Ontario (PJ/year)

| Manure | Total resource [a] (PJ/year) | Technical resource [b] (PJ/year) | Availability factor[c] | Practical resource (PJ/year) |
|---|---|---|---|---|
| Pigs | 11.9 | 5.9 | 50% | 3.0 |
| Dairy cows | 14.3 | 5.5 | 12.5% | 0.7 |
| Beef cows | 5.9 | 2.3 | 25% | 0.6 |
| Calves, steers and heifers | 6.6 | 2.5 | 25% | 0.6 |
| Chicken (Layer) | 2.3 | 0.9 | 0% | 0.0 |
| Chicken (Broiler) | 2.8 | 1.1 | 0% | 0.0 |
| Turkeys | 1.4 | 0.5 | 0% | 0.0 |
| **Total** | **45.1** | **18.7** | | **4.9** |

Note
a The total resource shows the energy that is contained in the manure, assuming a higher heating value of 14 GJ/tonne, and an ash content of 30%.
b The technical resource shows the energy that can be extracted from the manure, making use of the assumed conversion routes as indicated in the last column. It is calculated that pig manure digestion results in 6.98 GJ/tonne dry manure, cattle digestion in 5.34 GJ/tonne. For the others also 5.34 GJ/tonne were assumed.
c It is assumed that only manure that is released in stables can be collected for energy use. The shown availability factors are first estimates based upon existing experience with manure digestion. It would require detailed research beyond the scope of this study to verify these factors.

### WASTE WOOD

Waste wood consists of construction and demolition wood and forms a popular feedstock for biomass power plants. Emission controls are very important because

**TABLE 8**

Calculation of the production of animal manure in Ontario in 2001

| Manure | Number of animals in Ontario[a] | Average body mass of one animal[b] | Total animal body weight (1000 kg) | Total solids / 1000 kg animal mass per day[b] | Total solid manure/year (tonnes /year) | Total energy potential (combustion) (PJ/year) |
|---|---|---|---|---|---|---|
| Pigs | 3,457,346 | 61 | 210,898 | 11 | 846,756 | 11.9 |
| Dairy cows | 363,544 | 640 | 232,668 | 12 | 1,019,087 | 14.3 |
| Beef cows | 376,020 | 360 | 135,367 | 8.5 | 419,977 | 5.9 |
| Calves, steers and heifers | 1,376,732 | 91 | 125,283 | 10 | 468,714 | 6.6 |
| Chicken (Layer) | 15,693,374 | 1.8 | 28,248 | 16 | 164,969 | 2.3 |
| Chicken (Broiler) | 27,931,322 | 0.9 | 25,138 | 22 | 201,860 | 2.8 |
| Turkeys | 3,402,697 | 6.8 | 23,138 | 12 | 101,346 | 1.4 |
| **Total** | | | | | **3,222,707** | **45.1** |

Note
a Source: STATCAN 2004, the data refers to 2001.
b Source: ASAE, *ASAE D384.1 DEC99 Manure production and characteristics*. American Society of Agricultural Engineers: St. Joseph (USA), 2000.

some of this recovered material can be impregnated with preservatives or polluted with paint. The total annual quantity of construction and demolition sources available in Ontario is about 842 kt.[40] It is assumed that about 40 percent of this quantity consists of demolition wood, equaling 337 kt, which is equivalent to 4.7 PJ of energy. It should be possible to collect at least 80 percent of this quantity, forming a technical resource of 3.8 PJ, which can also be regarded as the practical resource.

### BIODEGRADABLE MUNICIPAL SOLID WASTE

The organic fraction of municipal solid waste (MSW) can be regarded as a source of renewable energy and it is referred to as biodegradable municipal waste (BMW). In Ontario, 6.6 million tonnes of MSW were released in 2000 from residential, industrial, commercial, and institutional sources, of which an estimated 50% can be regarded as BMW.[41] With an estimated energy value of 11 GJ/tonne the total resource of the 3.3 million tonnes is 36.3 PJ/year, which is considered as the total resource. The environmental concerns regarding incineration are numerous; therefore, incineration is not considered in the technical and practical resources analyzed here. The introduction of incineration would also displace some of the energy generation estimates from landfill gas as both energy recovery systems are relying on the same organic waste component as the energy source.

### LANDFILL GAS

All landfills produce gas as waste decomposes, which is generated during a 30–50 year period, and continues after the closure of the landfill. Landfill gas consists of approximately 50% methane and 50% carbon dioxide, which are both greenhouse gases. One tonne of methane is equivalent to 21 tonnes of carbon dioxide in terms of global warming potential. Landfill sites generate over a quarter of the methane emissions caused by human activity in Canada, sending 1,200 kilotonnes (kt) of this potent greenhouse gas into the atmosphere each year.[42] In 1999, 290 kilotonnes of methane were collected and either flared or used to produce energy in Canada thereby preventing the release of methane to the atmosphere.[43] Extrapolating this data to Ontario, which generates 35% of the residential municipal waste in Canada, indicates that approximately 423 kilotonnes of methane is available from landfills in Ontario, which corresponds to a total resource of 20 PJ. It is estimated that half of this quantity (10 PJ) could technically be collected. On a national level, the federal government plans to double the present capture of landfill gas. Extrapolated to Ontario this represents a practical resource of 9.6 PJ.

### SEWAGE GAS

During the treatment of urban and industrial wastewater, recovered sewage gas can be used for energy purposes. Over 78% of Canadians are now using sewage systems connected to some type of wastewater treatment plant. In most cases, these plants use some of the methane produced during decomposition to heat their digesters. In at least nine plants, the methane is used in a cogeneration mode. The total installed capacity is estimated at 17 MW with an estimated annual generation of 58 GWh.[44]

Sewage sludge is a residual product from the treatment of urban and industrial wastewater. In Canada approximately 388,700 tonnes of sewage sludge are produced every year[45]. About 43% of these bio-solids are applied

to land, 47% are incinerated and 4% are sent to landfill. Because of the high moisture content, combustion generally takes place without net energy recovery.

No data was found on the potential energy captured in sewage gas from wastewater treatment. However, assuming 35% of Canada's sewage sludge and gas are released in Ontario, and assuming that one tonne of sewage sludge indicates a quantity of 6 GJ of energy from the sewage gas, the total resource of sewage gas is 0.8 PJ. The technical and practical resources are estimated at 0.6 and 0.4 PJ, respectively.

## 4. Overview: the total, technical, and practical resources available

Table 9 summarizes the total, technical and practical biomass resource in Ontario expressed in PJ (the total resource is equal to 848.5 PJ of primary energy).

The total resource represents the total quantity of biomass that is potentially available, not taking into account environmental, technical and logistical considerations.

**TABLE 9**

Overview of the resource availability of biomass in Ontario (PJ, primary energy)

| Supply sector | Type | Total resource | Technical resource | Practical resource |
|---|---|---|---|---|
| Forestry | Spent liquor and waste wood | 377 | 229 | 83[a] |
| | Bark | | | 29 |
| | Fuel wood | | | 16.7 |
| | Sawdust | | | 13.7 |
| | **Subtotal** | | | **142.4** |
| Agriculture | Energy crops | 103 | 103 | 103 |
| | Field crop residues | 113 | 64 | 17 |
| | Grains and grain milling residues | 99 | 5.0 | 5.0 |
| | Livestock manure | 45 | 19 | 4.8 |
| | **Subtotal** | | | **129.8** |
| Organic waste | Landfill gas | 20 | 10 | 9.6 |
| | Waste wood | 4.7 | 4.7 | 3.8 |
| | Residues from food industry | 50 | 10 | 2.3 |
| | Sewage sludge | 0.8 | 0.6 | 0.4 |
| | Biodegradable municipal waste | 36 | 0 | 0 |
| | **Subtotal** | | | **16.1** |
| **Total** | | **848.5** | **445.3** | **288.3** |

Note:
a This resource estimate from NRCan appears somewhat high given the energy content of black liquor. It may include imported wood, recycled paper, and a possible double counting of some of the bark and sawdust component indicated under the forestry sector. This figure requires further analysis.

The technical potential, representing the quantity of biomass that could be obtained in an environmentally-sustainable way with the help of state-of-the-art technologies, is estimated at 445 PJ of primary energy.

The practical potential does not take into account financial constraints, such as low heat and electricity prices, or high technology costs. However, it does take into account avoiding conflicts with existing uses of biomass. The practical potential of 288 PJ shows the resource that could be practically realized within a timeframe of 10 years. Of this resource, approximately 142 PJ would come from the forest sector while 130 PJ would come from the agricultural sector and 16 PJ from the waste recovery sector from urban areas. The estimates of incremental bioenergy would be 20 PJ from the forest sector, 130 PJ from the agricultural sector and 10 PJ from the urban waste sector, for a total of 160 PJ.

## 5. Ontario's achievable biomass contribution

The contribution of biomass to the energy supply is divided into a short-term and long-term component. The long-term contribution is referred as the "achievable contribution," and the short-term contribution is referred as the "estimated contribution".

- The achievable contribution shows the amount of bio-energy that can be generated within 10–20 years with present and promising new technologies and with substantial financial incentives using the biomass types and volumes indicated as the practical resource.
- The estimated contribution shows the amount of bio-energy that can be generated within four years with present technologies and with modest financial incentives using the biomass types and volumes indicated as the practical resource.

### 5.1 ACHIEVABLE CONTRIBUTION (2010–2020)

Table 10 shows the achievable contribution, utilizing the practical resource with the most efficient technologies. For power generation combined heat and power systems are used as the preferred technology.

The achievable contribution consists of 14.7 TWh (53 PJ) of electricity and 169 PJ of heat, in total 69.0 TWh (222 PJ) of secondary energy. About 14.7 TWh of

electricity can be generated, which corresponds with a generating capacity equivalent to 2,450 MW. In this scenario, 47.0 TWh (169 PJ) of heat is also produced, part of which could displace large amounts of grid power by substituting for electrical heating in residential applications. About 288 PJ of biomass is utilized. It corresponds roughly with 16.1 million tonnes of biomass per year. This resource can be obtained and utilized in a sustainable way, but care should be taken to meet all conditions of environmentally-sound production.

## 5.2 ESTIMATED CONTRIBUTION (2007)

The estimated contribution takes into account present use of bio-energy, market conditions and financial/economic factors, and could be realized in 2007. The following assumptions have been made:

- The present use of waste wood and black liquor is estimated at 83 PJ. Note that the black liquor is combusted not only for heat production, but primarily for recovery of chemicals dissolved in the liquor. Therefore, it is not known whether in the present situation all heat produced in this sector is used efficiently, or partly wasted. However, for the determination of the estimated contribution it is assumed that 15% CHP and 85% heat generation is applied, and that all resulting heat and electricity can be used in the process.
- CHP is a relatively expensive application. It is assumed that 85% of the bark is combusted for heat production and that 15% is used for CHP.
- 16.7 PJ of wood fuels is presently used in households. It is expected that this situation will not change.
- Sawdust is sold on the Ontario market for heat production and burned as sawdust or wood pellets.
- About 50% of the available straw type agricultural residues are used for heat generation, replacing electricity, heating oil and propane. Collection and pre-treatment systems have to be implemented, which will take time.
- About 10% of the potential for energy crops is developed mainly for domestic heat production, replacing mainly electricity, heating oil, propane and natural gas. It is assumed that production is low in the initial years, as some time is needed for establishment of energy crops and to introduce densification and combustion equipment.
- 20% of the practical resource of manure is utilized for CHP production, assuming that the relatively

**TABLE 10**

Overview of achievable contribution of biomass in Ontario (PJ)

| Supply sector | Type | Practical resource $PJ_{prim}$ | Utilization % | Used biomass $PJ_{prim}$ | Application | Power $PJ_{sec}$ | Heat $PJ_{fuel}$ |
|---|---|---|---|---|---|---|---|
| Forestry | Bark | 29 | 50% | 14.5 | H | | 12.3 |
| | | | 50% | 14.5 | CHP[a] | 4.4 | 6.5 |
| | Spent liquor and waste wood | 83 | 100% | 83 | CHP | 24.9 | 37.4 |
| | Sawdust | 13.7 | 100% | 13.7 | H[b] (wood pellets) | | 11.6 |
| | Fuel wood | 16.7 | 100% | 16.7 | H | | 14.2 |
| Agriculture | Agricultural residues | 17 | 50% | 8.5 | H | | 7.2 |
| | | | 50% | 8.5 | CHP | 2.6 | 3.8 |
| | Energy crops | 103 | 50% | 51.5 | H | | 43.8 |
| | | | 50% | 51.5 | CHP | 15.5 | 23.2 |
| | Grains and Milling residues | 5.0 | 100% | 5.0 | H | | 4.3 |
| | Livestock Manure | 4.8 | 100% | 4.8 | CHP (anaerobic digestion)[c] | 1.4 | 2.2 |
| Organic waste | Residues from food industry | 2.3 | 100% | 2.3 | CHP | 0.7 | 1.0 |
| | Waste wood | 3.8 | 100% | 3.8 | CHP | 1.1 | 1.7 |
| | Landfill gas | 9.6 | 100% | 9.6 | P | 2.4 | |
| | Sewage sludge | 0.4 | 100% | 0.4 | CHP (anaerobic digestion)[c] | 0.1 | 0.2 |
| Total | | 288.3 | | 288.3 | | 53.0 | 169.4 |
| **Total – TWh** | | | | | | **14.7** | |

Note
a CHP with an anticipated net electric and thermal efficiency of 30 and 45%, respectively.
b Heat applications have an assumed thermal efficiency of 85%, indicating an optimal match with the heat demand.
c Anaerobic digestion has an assumed net electric and thermal efficiency of 20 and 30%, respectively.

expensive technology is applied at the most suitable sites (i.e. those with a high heat demand and abundant manure supply).
- Used frying oil (food industry) can be co-combusted in natural gas heated power plants.
- Waste wood can be combusted for CHP production. The costs of the plant could be financed from fees for waste disposal; it is also assumed that highly efficient environmental control technology is applied to meet strict emissions limits.
- Presently, landfill gas is partly utilized, and the low electricity generating costs of 0.04 $/kWh suggest that it is financially feasible to utilize the potential of 9.6 PJ primary energy optimally.
- Biodegradable municipal waste is only used for landfill gas production.

The estimated contribution is presented in Table 11 and indicates that about 2.5 TWh (9.1 PJ) of electricity can be achieved, which corresponds with a generating capacity of 426 MW.

More electricity generating capacity can be installed if a financial incentive of 4 cents per kWh is available to make large biomass CHP production financially feasible.

In total, 113.7 PJ of heat is generated, of which 74 PJ (65%) with black liquor, wood waste and bark to be used as process heat, and 40 PJ (35%) with other biomass (wood fuels and pellets from sawdust, agricultural residues and energy crops) to be used for heating in the residential and commercial sectors (see Ontario Energy Appendix for a description of these sectors).

With the 40 PJ of non-process heat, a major reduction in the use of electricity heating oil and propane could be achieved given the favourable economics of biomass heat substitution for these commodities at current prices.

## 5.3 GROWTH QUICKENS IN NEW MARKETS

As sales of biomass systems, such as pellet stoves and boilers increase, reductions in prices can be achieved through economies of production. Other biomass systems can achieve faster market penetration rates if stable investment support mechanisms are provided in conjunction with clear guidelines for systems performance (to decrease the complexity of permitting processes).

**TABLE 11**

Overview of estimated contribution of biomass in Ontario (PJ)

| Supply sector | Type | Practical resource $PJ_{prim}$ | Utilization % | Used biomass $PJ_{prim}$ | Application | Power $PJ_{sec}$ | Heat $PJ_{fuel}$ |
|---|---|---|---|---|---|---|---|
| Forestry | Bark | 29 | 50% | 14.5 | H | | 12.3 |
| Forestry | Bark | 29 | 85% | 24.7 | H | | 17.3 |
| | | | 15% | 4.4 | CHP[a] | 1.3 | 2.0 |
| | Spent liquor and waste wood | 83 | 85% | 70.6 | H | | 49.4 |
| | | | 15% | 12.5 | CHP | 3.8 | 5.6 |
| | Sawdust | 13.7 | 100% | 13.7 | H[b] (wood pellets) | | 9.6 |
| | Fuel wood | 16.7 | 100% | 16.7 | H | | 11.7 |
| Agriculture | Agricultural residues | 17 | 50% | 8.5 | H | | 6.0 |
| | Energy crops | 103 | 10% | 10.3 | H | | 7.2 |
| | Grains and Milling residues | 5.0 | 100% | 5.0 | H | | 3.5 |
| | Livestock Manure | 4.8 | 20% | 1.0 | CHP (anaerobic digestion) | 0.3 | 0.4 |
| Organic waste | Residues from food industry | 2.3 | 70% | 1.6 | P (co-combus-tion)[c] | 0.6 | |
| | Waste wood | 3.8 | 50% | 1.9 | CHP | 0.6 | 0.9 |
| | Landfill gas | 9.6 | 100% | 9.6 | P | 2.4 | |
| | Sewage sludge | 0.4 | 100% | 0.4 | CHP (anaerobic digestion) | 0.1 | 0.2 |
| Total | | 288.3 | | 180.9 | | 9.1 | 113.7 |
| **Total – TWh** | | | | | | **2.5** | |

Note.
a CHP with an anticipated net electric and thermal efficiency of 30 and 45%, respectively.
b Heat applications have an assumed thermal efficiency of 70%.
c Co-combustion of used frying oil is possible in a natural gas or oil fired electricity plant with an estimated efficiency of 40%.

## 6. Policies, mechanisms, and incentives to enhance biomass implementation

The implementation of biomass resources, as all other renewable energy sources, requires stable investment conditions. These conditions can be established through renewable energy mechanisms, which can be specifically tailored to increase market penetration of the most promising biomass technologies. This strategy is currently being used in Germany to support the development of anaerobic digestion of farm manure. Through this strategy, Germany has achieved the highest market penetration of that technology in Europe, while other European countries that have a similar resource base but lack renewable energy mechanisms (e.g. United Kingdom) have not achieved positive results.[46]

Adoption rates for smaller biomass systems for heat generation only (e.g. pellet stoves and boilers) will increase if supporting mechanisms are facilitated. The province should secure support from the federal government to establish a revolving loan system to provide low interest loans to enable home and business owners currently relying on electric heat, oil, natural gas and propane to purchase these new biomass appliances. Provincial and federal cooperation in this area constitutes a natural fit under common efforts to decrease greenhouse gas emissions and sustainable cities agendas.

Through the use of renewable energy mechanisms and a revolving loan system to support biomass heating systems, Ontario can establish a stable biomass market that will enable farmers and forestry operators to profit from their residues, energy crops and biomass products. Municipalities also need to provide leadership in helping develop district-heating systems to support their forest and agricultural resource-based communities.

The development of an integral biomass action plan to address issues such as financial incentives, public awareness, technology development, permits and procedures is essential for accelerating the development of biomass.

## 7. Conclusions, recommendations and further research

Analysis of Ontario's biomass potential shows that a total capacity of 426 MW of biomass-generated electricity could exist in Ontario by 2007 and 2,450 MW between 2010-2020. This capacity is higher than estimated in two recent studies. The report *Power to the Future* estimates that in 2020 the equivalent of 800 MW of biomass capacity can be installed in Ontario.[47] The report *Tough Choices* estimates that new biomass energy could provide the equivalent of an additional 1,700 MW of power.[48]

The difference in results can be explained by the fact that in this study, the biomass resource was investigated in more detail by covering several sectors that could supply additional biomass. In this report, the agricultural sector was identified as having the potential to create a large new energy supply that could make a significant contribution to Ontario's energy supply.

Provincial biomass resources and contributions were estimated with the best information presently available. However, the province needs to develop a model that incorporates economic effects of different resource-technology combinations in detail to derive accurate financial support instruments and detailed policy development.

The province will also benefit from commissioning follow-up studies to accurately estimate the quantities of residues from the forestry sector and its related industries, an area where not much information is currently available in Ontario.

Finally, in the pulp and paper industry significant amounts of biomass are currently used and it would be quite useful to investigate whether the biomass is utilized efficiently, and to determine if further optimization is possible, for instance by the introduction of CHP-plants for black liquor and bark.

Through follow-up studies, the province will achieve a comprehensive scenario covering all relevant biomass options and their pertinent caveats, which constitutes an essential step to formulate sustainable transition paths.

## QUEBEC COMPANY TURNS BIOMASS INTO ENERGY

A new form of renewable energy that turns fast growing grasses into a low-cost, environmentally-friendly means of heat energy is changing the rural energy market in Quebec.

Dell-Point Technologies of Blainville, Quebec, has designed a biomass fuel in the form of pellets made from switchgrass. Dell-Point tested various agricultural biofuels for producing pellets. It found switchgrass to be the most economical as it lowered processing costs by being easier to pellet and required minimal drying compared to wood. Pelleted switchgrass burns at the same efficiency as oil in a high efficiency oil furnace.

The pellets are burned in stoves, much like a wood or gas stove. Most pellet stoves are vented through a wall as compared to their wood counterpart. A hopper on the back of the stove can hold up to 60 pounds of fuel, which is then automatically fed to the combustion chamber, according to how much heat is required. Pellet fuel is easier to load and store than wood and has a much longer burning cycle. The pellet stoves are equipped with blowers that force hot air into the room through a heat exchanger located on the front of the stove.

The technology reduces space heating costs by 50 percent or more. Switchgrass pellets are only half the cost of conventional fuels for farmers.

## Biomass Appendix

Table 1 shows an estimate of the costs of landfill gas utilization, and co-combustion which total 4.5 and 6 cents/kWh. The cost of the landfill gas is set at zero as it is assumed that the owner of the landfill site receives a waste disposal fee. Options such as CHP-combustion are more expensive (11 cents/kWh). Because anaerobic digestion is generally applied at a relatively small scale its cost is estimated at 17 cents/kWh which although makes it a more expensive option, but one that can be more easily implemented because of its small scale, the availability of manure, and demand for heat at farm level.

**TABLE 1**

Costs of electricity generation with biomass

| | | Co-combustion with coal | Large CHP-combustion | Landfill gas | Anaerobic digestion (manure) |
|---|---|---|---|---|---|
| Capacity | MWe | 50 | 30 | 1 | 0.04 |
| Investment costs | $/kWe | 500 | 3,000 | 1,750 | 8,000 |
| Operational time | hours/year | 7,500 | 7,500 | 7,000 | 6,500 |
| Energy content | GJ/ton | 15 | 15 | – | – |
| Fuel costs | $/ton | 90 | 90 | 0 | 0 |
| Fuel costs | $/GJ | 6 | 6 | – | – |
| Electric efficiency | % | 40% | 30% | 25% | 20.0% |
| Thermal efficiency | % | 0% | 45% | 0% | 30% |
| Electricity production | MWhe | 375,000 | 225,000 | 7,000 | 260 |
| Saleable heat production | GJ | 0 | 1,215,000 | 0 | 1,404 |
| Lifetime on investment | years | 10 | 10 | 10 | 10 |
| Discount rate | % | 8% | 8% | 8% | 8% |
| Total investment | $ | 25,000,000 | 90,000,000 | 1,750,000 | 320,000 |
| Annual capital costs | $ | 3,725,737 | 13,412,654 | 260,802 | 47,689 |
| Annual O&M costs (7-10% of ann. capital costs) | $ | 260,802 | 938,886 | 26,080 | 4,769 |
| Biomass costs | $ | 20,250,000 | 16,200,000 | 0 | 0 |
| Total production costs | $ | 24,236,539 | 30,551,540 | 286,882 | 52,458 |
| Production costs electricity (excl. sale of heat) | $/kWh | 0.065 | 0.136 | 0.041 | 0.202 |
| Sales price heat | $/GJ | – | 9 | – | 9 |
| Income from sold heat | $ | – | 10,935,000 | – | 12,636 |
| Production costs electricity (incl. sale of heat) | $/kWh | 0.065 | 0.087 | 0.041 | 0.153 |

**TABLE 2**

Source data and analysis for Figure 3: solar energy collection and fossil fuel energy requirements of Ontario crops, in giga-joules (GJ) per hectare

| Crop | Yield[e] (ODT/ha) | Energy content (GJ/ODT) | Fossil energy consumed/tonne produced (GJ/ODT) | Fossil energy consumed/ ha of production (GJ/ha) | Energy content/ha (GJ/ha) | Energy content/ha less fossil energy consumed/ha production (GJ/ha) |
|---|---|---|---|---|---|---|
| Oats | 2.1 | 19.1[a] | 2.5[b] | 5.25 | 40.11 | 34.86 |
| Rye | 2.2 | (19.0)[g] | 2.5[b] | 5.50 | 41.80 | 36.30 |
| Soybeans | 2.2 | 23.8[a] | 2.0[b,f] | 4.40 | 52.27 | 47.87 |
| Canola | 2.2 | 25.0[h] | 2.5[b] | 5.50 | 55.00 | 49.50 |
| Barley | 3.2 | (19.0)[g] | 2.5[b] | 8.00 | 60.80 | 52.80 |
| Winter wheat | 4.1 | 18.7[a] | 2.5[b] | 10.25 | 76.67 | 66.42 |
| Grain corn | 5.2 | 18.8[a] | 3.5[b,f] | 18.20 | 97.76 | 79.56 |
| Tame hay | 6.3 | 17.9[a] | 0.8[b] | 5.04 | 112.77 | 107.73 |
| Switchgrass | 9.0[i] | 19.0[c] | 0.8[d] | 7.20 | 171.00 | 163.80 |

Notes on sources:

a. Agricultural Utilization Research Institute. AURI Fuels Initiative. (http://www.auri.org/research/fuels/fuel.htm).

b. Estimates based on: Southwell, P.H. and T.M. Rothwell. 1977. *Report on analysis of output/input energy ratios of food production in Ontario*. School of Engineering, University of Guelph. Contract Serial No. OS276–00048.

c. Samson, R. and P. Duxbury. 2000. *Assessment of Pelletized Biofuels.* REAP-Canada. (http://www.reap-canada.com/Reports/pelletaug2000.html).

d. Girouard P., C. Zan, B. Mehdi. and R. Samson. 1999. Economics and Carbon Offset Potential of Biomass Fuels: Final Report. Federal Panel on energy Research and Development (PERD). Contract 23341-6-2010/00 1/SQ.

e. Ontario Ministry of Agricultural and Food. 2001. Ontario Crop Statistics 1997–2001. (http://www.gov.on.ca/OMAFRA/english/stats/crops/index.html).

f. Swanton C.J., S.D. Murphy, D.J. Hume, D.R. Clements. 1996. *Recent Improvements in the Energy Efficiency of Agriculture: Case Studies from Ontario, Canada*. Agricultural Systems. 52: 399–418.

g. Estimate based on energy contents of other cereal grains. REAP-Canada.

h. Personal communication from Dell-Point Technologies.

i. Yield estimate from REAP-Canada based on pre-commercial field studies.

## BIOMASS CHAPTER NOTES

1 Samson R., M. Drisdelle, L. Mulkins, C. Lapointe, and P. Duxbury. (2000a). *The Use of Switchgrass Biofuel Pellets as a Greenhouse Gas Offset Strategy*. Bioenergy 2000. Buffalo, New York: bioenergy 2000. Available at: http:/www.reap-canada.com/Reports/bioenergy2000Aug2.html

2 All figures are for 2001 and are from Ericsson, K., Huttunen, S., Nilsson, J. and Svenningsson, P. (2004). Bioenergy policy and market development in Finland and Sweden. *Energy Policy*, 32 (15), 1707–1721.

3 Ibid.

4 Sims, R., Richards, K. (2004). *Bioenergy for the global community*. *Renewable Energy World*, 7 (1), 8–133.

5 Jannasch, R., R. Samson, A. De Maio and T. Helwig. (2001). Switchgrass Fuel Pellet Production in Eastern Ontario: A Market Study. REAP-Canada Final Report to CANADAPT and the Agricultural Adaptation Council of Ontario. Ottawa: REAP-Canada.

6 Turkenburg et al. (2001). *World Energy Assessment: Energy and the Challenge of Sustainability*. New York: UNDP.

7 Jannasch et al. (2001) op.cit. note 5.

8 Source: Natural Resources Canada, Office of Energy Efficiency available online at: http://oee1.nrcan.gc.ca/Neud/dpa/trends_res_on.cfm

9 A series of case studies and backgrounders on the different types of biomass heating systems found in Ontario and in other provinces are available on the Natural Resources Canada web site. They include reports on:

- Residential Wood heating http://canren.gc.ca/prod_serv/index.asp?CaId=103&PgId=576
- Wood Chip Heating systems for farms and small commercial applications http://www.canren.gc.ca/prod_serv/index.asp?CaId=130&PgId=729

  http://www.canren.gc.ca/prod_serv/index.asp?CaId=162&PgId=860

  http://www.canren.gc.ca/renew_ene/index.asp?CaId=47&PgId=738
- District heating systems http://canren.gc.ca/prod_serv/index.asp?CaId=184&PgId=1091

  http://www.canren.gc.ca/renew_ene/index.asp?CaId=47&PgId=975

  http://www.canren.gc.ca/renew_ene/index.asp?CaId=47&PgId=956

  http://www.districtenergy.org/CHP_Case_Studies/University_of_Iowa.pdf

10 A cogeneration case study can be found at: http://www.canren.gc.ca/renew_ene/index.asp?CaId=47&PgId=1194

11 The first generation of BIGCC systems shows high unit capital costs. Depending on the scale, prices are in the range of $4,000–7,000 per kW, but cost reduction potential is considerable -capital costs might come down to $1,500–2,800 per kW.

12 Anaerobic digestion also takes place in the treatment of urban and industrial waste waters. Sewage gas is recovered as part of the process, which can be used for energy purposes. Usually the recovered heat is used at the treatment plants. More background information can be found at: http://www.canren.gc.ca/prod_serv/index.asp?CaId=170&PgId=970

13 Biogas production occurs naturally, amongst others in swamps and lakes when conditions are right. In a tank or container conditions can be created to optimize biogas production from manure and organic materials. Biogas production also takes place in landfills. The biogas is then usually called landfill gas.

14 See page 126 of Tijmensen, M., van den Broek, R. (2004). Clean power from farm waste: international experiences with anaerobic digestion of farm manure. *Renewable Energy World*, 7 (2), 124–131.

15 Ibid.

16 A NRCan case study on landfill gas can be found at: http://www.canren.gc.ca/renew_ene/index.asp?CaId=47&PgId=1121

17 Tampier, M. (2002). *Promoting Green Power in Canada, Green Power Policies: A Look Across Borders*. Toronto: Pollution Probe. Available at www.pollutionprobe.org/Reports/greenpower.pdf

18 Von Hammerstein. (2004). Facing the future: what new policy will mean for wind in Germany. *Renewable Energy World*, 7 (3), 88–97.

19 See Sims, R. (2003). Bioenergy to mitigate for climate change and meet the needs of society, the economy and the environment. *Mitigation and Adaptation Strategies for Global Change,* 8 (4), 349–370 and Sims and Richards (2004) op.cit note 4.

20 This chapter estimates that Ontario could generate 2,500 GWh/year by 2007 and 14,700 GWh/year by 2020 from biomass sources.

21 Agriculture and Agri-Food Canada's February 2004 Forecast – Farm Cash Receipts, Expenses and Income for 2002 and 2003 available at www.agr.gc.ca/spb/fiap-dpraa/publications/frcstprev/forcst03_e.php

22 The Walkerton Inquiry revealed that the key physical source of contamination behind the Walkerton tragedy was manure that had been spread on a farm near a drinking well; the manure was contaminated with *E.coli* bacteria and Campylobacter strains, which unfortunately became the source of a deadly human outbreak of *E.coli* in the Town of Walkerton in 2000. O'Connor, D. (2002). *Report of the Walkerton Inquiry*. Toronto: Ontario Ministry of the Attorney General.

23 Lowe et al. (1996). Penner et al. (1997) provide estimates to derive the total (woody) biomass resource from

numbers of timber productive wood and distinguish two productivity classes of forest. Productivity class I is forestland incapable of producing a merchantable stand. Productivity class II is forestland capable of producing a merchantable stand within a reasonable length of time, and can be related to Canada's Forest Inventory. See: Lowe, J.J., K. Power, and S.L. Gray, (1996). *Canada's Forest Inventory 1991: the 1994 version. An addendum to Canada's forest inventory 1991. CFS Information report BC-X-362E.* Victoria: Canadian Forest Service. Penner, M., et al. (1997). *Canada's Forest Biomass Resources: Deriving estimates from Canada's Forest Inventory*, Victoria: Pacific Forestry Centre.

24 Derived with help of average biomass density (87 t/ha) and timber productive area (42.2 mln ha) as stated in Penner et al. (1997) and Lowe et al. (1996) op.cit. note 23.

25 Source: National forest database program http://www.nfdp.ccfm.org/

26 These factors are investigated in detail in Penner et al. (1997) op.cit note 23.

27 Courtesy of BTG

28 For more details see www.fsc.org

29 Other technologies like black liquor gasification are described in Tam, P., et al., *Forest sector table: assessment of gasification technologies and prospects for their commercial application*. 1999, Forest Sector Table National Climate Change Process: Richmond, B.C. Black liquor can lead to emissions of dioxins and furans (dioxins are known carcinogens). For more information see Uloth, V. van Heek, R. (2002). Dioxin and Furan Emission Factors for Combustion Operations in Pulp Mills, Report Prepared for Environment Canada. PAPRICAN: Prince George, BC. Available at: www.ec.gc.ca/pdb/npri/2002guidance Emission_Factor_Report_for_Combustion_Ops_in_Pulp_Mills.pdf

30 Natural Resources Canada, Office of Energy Efficiency, Historical Databases – February 2003, retrieved May 2004 from http://oee1.nrcan.gc.ca/Neud/dpa/comprehensive_tables/

31 Hatton, T. (1999). *Canada's Wood Residues, a profile of current surplus and regional concentrations*. Canadian Forest Service, Industry, Economics and Programs Branch. Available at www.nccp.ca/NCCP/pdf/Canada's_Wood_Residues.pdf

32 Natural Resources Canada, Office of Energy Efficiency, Historical Databases – February 2003, retrieved May 2004 from http://oee1.nrcan.gc.ca/Neud/dpa/comprehensive_tables/

33 Table derived using: Tam, P., et al. (1999). *Forest sector table: assessment of gasification technologies and prospects for their commercial application*. Richmond: Forest Sector Table National Climate Change Process; National forest database programme http://www.nfdp.ccfm.org; and Natural resources Canada, Office of Energy Efficiency, Historical Databases – February 2003, retrieved May 2004 from http://oee1.nrcan.gc.ca/Neud/dpa/comprehensive_tables/

34 Madakadze C, Coulman BE, McElroy AR, Stewart KA and Smith DL. (1998). Evaluation of selected warm season grasses for biomass production in a short season area. *Bio Resource Technol*, 65, 1–12. Arvid Boe, South Dakota State University, personal communication.

35 Corn stover are the stalks and leaves and cobs of the corn plant.

36 Helwig, T., et al. (2002). *Agricultural biomass residue inventories and conversion systems for energy production in Eastern Canada*. Ste. Anne de Bellevue, Quebec: Resource Efficient Agricultural Production (REAP).

37 Ibid.

38 Germany and Denmark have accumulated significant experience with anaerobic digestion. Digested manure can be used as fertilizer avoiding the loss of important nutrients. Although the manure of chickens and turkeys is suitable for combustion and gasification using emission controls (as it is done in the Netherlands and the United Kingdom), its incineration prevents its application as a fertilizer.

39 Tampier, M., E. Bibeau, and P.A. Beauchemin. (2003). *Identifying environmentally preferable uses for biomass resources, draft stage 1 report: identification of feedstock-to-product threads.* North Vancouver, B.C: Envirochem services Inc.

40 Source: Statistics Canada: Disposal of waste by source, by provinces and territories available at: www.statcan.ca/english/Pgdb/envi25a.htm

41 Ibid.

42 See Environment Canada's online article: 'Harnessing the Power of Landfill Gas'. Available at http://www.ec.gc.ca/science/sandemay99/article1_e.html

43 Pneumaticos, S. (2003). *Renewable Energy in Canada, Status Report 2002*. Renewable Ottawa: NRCan. Available at www2.nrcan.gc.ca/es/oerd/english/View.asp?x=700

44 Ibid.

45 Tampier et al. (2003) op. cit. note 39.

46 Although the U.K. has a comparable manure production to Germany's, it currently has only a few demonstration plants (both countries have two of the largest manure production rates of western Europe); see Tijmensen and van der Broek (2004) op.cit. Note 14.

47 This estimation is based on the following information: 100 MWe of generating capacity could be provided through landfill gas recovery; between 200 and 500 MWe of capacity might be provided through the use of methane from anaerobic digestion of various waste streams; and the remaining needed capacity could be provided by combustion of agricultural and wood waste.

48 It is stated that biomass energy is generated primarily from burning waste products such as landfill gas, wood chips from forestry operations and animal waste. The number is not further justified.

# 5 Geothermal Heat Pumps

## Summary

Geothermal heat pumps are the most cost-effective option to provide space heating and cooling in Ontario.

The implementation of geothermal heat pumps is a key strategy to displace electricity use and fossil fuels currently used for heating and cooling in residential and institutional/commercial buildings.

By displacing electricity use and fossil fuels, the technology represents a very cost-effective greenhouse gas mitigation strategy.

Geothermal heat pumps can be used across the province and are especially attractive for new buildings.

Manitoba Hydro has become a Canadian leader in deploying geothermal heat pumps, and provides an exemplary implementation template for Ontario.

The province should use its procurement ability to purchase geothermal heat pumps for provincial and municipal buildings to facilitate a market transformation in the institutional/commercial building sector.

The federal and provincial governments should collaborate, as part of their climate change mitigation efforts, to implement a revolving loan system to provide access to interest-free loans for the purchase of geothermal heat pumps.

## 1. Background

Geothermal heat pumps are one of the least-understood renewable energy options in Ontario partly because the technology (once installed) is out of sight, and partly because the industry interchangeably uses for the same concept a variety of terms: earth energy, GeoExchange, and ground-source heat pump.

Geothermal heat pumps are the most energy-efficient, cost-effective, and environmentally- friendly home heating and cooling systems available.[1] Heat pump technology works by moving heat out of, or back into the earth. Geothermal units are connected to the earth through pipes buried under a lawn, landscaped area, or even the building itself.

For this chapter, the term 'geothermal heat pump' (GHP) will be used to refer to ground-coupled heat exchangers that extract the stored energy readily available from the soil to meet all the needs for space heating, cooling and water heating (potable, service or pre-heat) of residential, institutional, commercial, and industrial buildings in the province.[2]

Of the solar radiation that reaches the earth, NASA estimates that more than half is absorbed into the near-surface land and water. GHP taps into this heat source below the frost line and 'upgrades' the temperature in a compressor before it is delivered as hot air or hot water. The secret to this technology is to collect small 'packets' of solar heat available from the soil, and to concentrate this thermal energy for use within a building's space.

This transfer of solar heat from the earth is achieved through the use of ground loops that can be installed in one of two basic configurations:[3]

- An 'open loop' that takes water from an aquifer, well or lake directly to a compressor, which extracts two to four degrees Celsius ($^{o}$C ) of thermal heat (or adds, in cooling mode) before the water is returned to its source[4];
- A 'closed loop' that circulates a diluted antifreeze through a pipe to absorb heat from the surrounding soil. The pipe is laid horizontally or, if the available

footprint is small, a 'coiled' loop is used to increase surface area for thermal transfer or, if land is very limited, vertical boreholes are drilled to transfer heat from deeper soil.

For cooling, the system is reversed, and heat from the building is transferred into the antifreeze or water for rejection into the outside 'heat sink,' in the same manner as a refrigerator takes heat from food and transfers it into a kitchen.

The amount of solar heat that is absorbed into the earth can be calculated by solar incidence charts. The ability of the soil to transfer this heat to the pipe (or its ability to absorb heat in cooling mode) can be assessed by a thermal conductivity analysis of the soil in which the pipe is buried.

During winter, the temperature of the earth's subsurface is warmer than average ambient (outdoor) air temperature, and cooler during summer. Below the frost line (average depth of 1.2 m across most of southern Ontario), the relatively constant temperature of the earth is close to the long-term mean annual ambient temperature, i.e.: 4° to 12° C throughout the year. Space conditioning systems in Toronto are designed to meet temperatures of –17.1° C in winter and 28.8° C in summer, and GHPs use this temperature differential to provide heating and cooling.

GHPs require electricity to power three system components: a circulating pump for the fluid in the loop; a compressor to execute the heat exchange process; and a distribution system for the hot air or radiant water. Overall efficiency is determined by a coefficient of performance (COP), which measures the amount of heat energy delivered to the space, divided by the electricity needed to operate the components. A COP of 3.0 means that 3 kW of usable thermal heat energy is transferred from the soil for every 1 kW of electricity consumed by components, for a net energy 'saving' of 2 kW.[5]

A variation of GHP technology is called Direct Expansion (DX), which uses copper pipe to circulate a refrigerant, rather than a liquid antifreeze. DX technology has a higher thermal transfer, but is a more expensive option and creates environmental concerns because it relies on a refrigerant buried in the earth.

The Canadian Standard Association accepted a standard in 2001 (CSA C4480), which regulates design and installation of both residential and commercial systems.

FIGURE 1 Residential GHP system

This standard has a section on 'underground thermal energy storage' to govern the use of caverns or aquifers to enhance heat transfer by use of a storage source/sink.

GHP is a 'distributed resource,' as it relies on energy that is sourced at or near the point of consumption. It does not require a centralized distribution system (e.g. natural gas pipeline) and its ability to reduce total power consumption (compared with electric heating/cooling) reduces transmission infrastructure and reduces grid congestion.

## 1.1 COSTS

The cost to install GHP systems is difficult to estimate because each site is specific, but this section will assume a residential 'high-average' total installed retail price of $20,000 for a new 2,000 ft$^2$ house in a Toronto or Ottawa subdivision, in a system designed to meet 100% of heating and cooling loads for space and domestic water.[6] Of this price, one-quarter ($5,000) is attributed to internal components (heat exchanger, compressor, fans, pumps, water desuperheater, etc) and the balance ($15,000) for excavation and installation of the outside loop. The GHP industry notes that installed prices can range from $10,000 to $23,000, depending on the type of soil and many other factors.[7]

In 1993, the Ontario Ministry of Environment and Energy estimated that GHP with a COP of 2.7 in a detached 2,000 ft$^2$ home in Toronto would cost $6,000 to $12,000 to install, and cost $790 a year for heating and cooling, and another $160 for water heating. It estimates the cost of heating with electric resistance would be $1,820 plus $490 for water heating.[8]

Manitoba Hydro offers a GHP loan of $15,000 for installed systems and estimates the cost of a new system in a 2,000-ft$^2$ home at $15,900 to $18,000, compared with $6,700 for electric baseboards; in a retrofit, GHP would cost

$11,400 to $16,500.[9] Annual space heating costs would be $400 compared with $1,001 for an electric furnace or electric baseboards, and $1,253 for a conventional (60% efficiency) gas furnace and $1,670 for a conventional oil furnace.[10]

The cost to install a GHP system in ICI facilities is difficult to estimate because building and occupant load profiles entail several distinct parameters. Analysis by Marbek (1999) found a low of $35,800 for a curling rink to a high of $756,336 for a seniors complex, both in Toronto.[11]

As far back as 1995, Natural Resources Canada estimated that in a detached home in Toronto it would cost $285 to $480 a year to operate an open loop GHP and $295 to $525 for a closed loop system (heating only) compared with $740 to $1,295 for an electric furnace.[12]

Using a 2004 cost comparison, Aquila Networks (now Fortis BC) estimates that a new single-family detached 2,000 $ft^2$ house in central British Columbia would require 20,000 kWh a year of heating/cooling, which would cost $530 a year from a GHP system, $1,244 from electric baseboard and $1,100 from mid-efficiency (78%) natural gas. Hot water would cost $142 with a GHP system, $293 with electricity and $273 with natural gas (for four occupants).[13]

In his budget of April 2004, Manitoba's Finance Minister said GHP could reduce heating costs by $400 to $800 a year compared with natural gas, and by $600 compared with all electric heating.[14] Manitoba Hydro supports the technology because it reduces local electricity use and therefore facilitates exports of electricity at high profit, while gas ratepayers avoid costly extensions of infrastructure into less-populated areas.

Manitoba Hydro has increased its marketing and communications support for GHP, including provision of attractive incentives and on-bill financing, and the province has negotiated federal incentives.

The Manitoba geothermal industry last year achieved a 40% growth rate. Manitoba is now first in Canada in total installations of GHPs, representing 30% of total new Canadian installations last year. GHP units are also being installed widely in commercial buildings, arenas, schools and other public buildings.

GHP is the least expensive source for thermal energy, based on an index of competing heating fuels, according to the Geo-Heat Center in Oregon.[15] GHP would cost $5.86 per million Btu of useful heating, compared with $7.14 for natural gas, $9.06 for fuel oil, $9.54 for air-source heat pump, $15.85 for propane and $20.51 for electric resistance heat.

## 1.2 GHP DEVELOPMENT

The International Energy Agency's Heat Pump Centre estimates that there are 500,000 GHPs currently installed around the world, with an estimated 45,000 new units added each year.[16] Its June 2004 newsletter reports on 2003 sales in three European countries:[17]

- The Swedish Heat Pump Association says that 48,806 heat pumps were installed (not including 25,000 air-to-air systems), of which GHP sales increased 15% to a total of 31,586 units;
- Germany reports that the market for heating-only heat pumps increased by 17% over 2002, with 9,745 space heating and 3,776 DHW systems sold;
- Sales in Norway were 55,000 units compared with 21,300 in 2002 and 6,300 in 2001, the majority of which were air-to-air systems. The Ministry of Petroleum & Energy provided a 20% subsidy for heat pumps, which result in 17,000 GHP systems in 2003.

GHP became popular in the United States because it could provide an alternative cooling technology to electric air conditioning. In a 1993 report, the Environmental Protection Agency noted that GHP was the best choice of five technology options for heating/cooling in all locations because it offered the lowest annual operating costs and lowest annualized costs, and was best for cutting greenhouse gas emissions.[18] That report led to the investment of $50 million (US) by governments and utilities (both private and public), and currently there are at least 21 states with financial incentives for GHP installations in the U.S.

The World Energy Council estimates that Canada had an installed capacity equivalent to 377,600 kW of low-temperature geothermal[19] in 2001, but there is no data available from the federal[20] or Ontario[21] governments for either existing capacity or thermal output from GHP.

The Earth Energy Society of Canada estimates that 35,000 systems have been installed across Canada, of which 30,000 are residential and the balance are institutional/commercial buildings. Its 'best guess' for Ontario's installations is 8,500 residential and 500 institutional/commercial building systems.[22]

Under a residential installation program funded by Ontario Hydro from 1990 to 1993, the Canadian Earth Energy Association administered the installation of 6,749 residential units in areas not served by natural gas.[23]

Currently, Fortis BC (formerly Aquila/West Kootenay Power) offers a rebate for residential and institutional/commercial building installations of GHP, and Manitoba Hydro offers a low-interest financing program for installations.

Some notable GHP facilities in Ontario include the University of Ontario Institute of Technology (one of the largest GHP installations on the continent); the new Parks Canada centre in Hamilton (the first in North America to use GHP with concrete piles); the Trustcan Realty office in downtown Toronto (the building was constructed above the boreholes to save land); Carleton University's aquifer thermal energy storage system; municipal water treatment facilities in Sudbury; and the Shadow Ridge subdivision near Ottawa that uses only GHP.

## 1.3 TECHNICAL CONSIDERATIONS

GHPs currently provide only space heating, space cooling and water heating. Models are under development to include refrigeration as part of the cycle. In addition to heating and cooling buildings, some of GHP's more unusual applications include crop drying, ice rink freezing, and road de-icing.

To assess the potential capacity for GHP in Ontario, the RETScreen software was used to model two basic building configurations.[24] A basic model examined a residence with 185 $m^2$ (2,000 $ft^2$) of floor space and GHP with minimum efficiency installed in heavy damp soil (representative of most of southern Ontario); and a commercial building of 9,290 $m^2$ (100,000 $ft^2$) using vertical boreholes on a low-efficiency unit in the same soil. Details are provided in the GHP Appendix.

To assess the potential contribution under a more mature market scenario, an advanced model increased insulation levels and upgraded heat pump efficiency, while the soil conductivity classification was increased one level.

Compared with a 'basic' Toronto/Ottawa residence that is heated and cooled by electricity, GHP can reduce power consumption by 59%[29], which increases to 73% under an 'advanced' scenario[30] and 80% when an 'advanced' GHP home is compared with a current 'basic' unit.[31]

GHP is classified as an 'electric' heating technology because it requires electricity to power its components. The above model assumes that GHP will displace buildings with all electric heating and cooling, but it should be noted that annual demand for electricity will increase if GHP is used to displace natural gas. However, each 'basic' residence would avoid combustion of 1,685 $m^2$ to 3,064 $m^2$ of natural gas each year.[32]

**TABLE 1**

GHP residential energy savings (annual kWh for space heating & cooling)

| | Energy demand[25] | GHP consumption[26] | GHP 'saving' |
|---|---|---|---|
| **Basic residence** | | | |
| Toronto | | | |
| – heating | 15,900 | 6,900 | 9,000 |
| – cooling | 13,600 | 5,000 | 8,600 |
| Ottawa | | | |
| – heating | 20,100 | 8,700 | 11,400 |
| – cooling | 11,000 | 4,300 | 6,700 |
| **Annual average[27]** | **30,300** | **12,500** | **17,850** |
| **Advanced residence** | | | |
| Toronto | | | |
| – heating | 8,100 | 2,500 | 5,600 |
| – cooling | 15,000 | 3,500 | 11,500 |
| Ottawa | | | |
| – heating | 10,400 | 3,100 | 7,300 |
| – cooling | 12,300 | 3,100 | 9,200 |
| **Annual average** | **22,900** | **6,100** | **16,800** |

NOTE: these data are for space heating and space cooling only, and do not reflect water heating, which accounts for 21% of residential energy consumption in Ontario.[28] GHP can provide 100% of domestic hot water load with a minor increase in run-time.

**TABLE 2**

Institutional / Commercial / Industrial (ICI) Energy Savings (annual kWh for space heating & cooling)

| | Energy demand | GHP consumption | GHP 'saving' |
|---|---|---|---|
| **Basic ICI** | | | |
| Toronto | | | |
| – heating | 448,000 | 208,000 | 240,000 |
| – cooling | 838,300 | 234,300 | 604,000 |
| Ottawa | | | |
| – heating | 515,200 | 232,800 | 282,400 |
| – cooling | 685,200 | 194,700 | 500,500 |
| **Annual average** | **1,243,300** | **434,900** | **813,400** |
| **Advanced ICI** | | | |
| Toronto | | | |
| – heating | 461,600 | 157,000 | 304,600 |
| – cooling | 570,300 | 109,000 | 461,300 |
| Ottawa | | | |
| – heating | 567,700 | 185,200 | 382,500 |
| – cooling | 464,700 | 88,900 | 375,800 |
| **Annual average** | **1,032,100** | **270,000** | **762,100** |

## 1.4 BENEFITS OF GHP

### ECONOMIC BENEFITS

Geothermal energy is the cheapest option for space heating and cooling.[33] Operating and maintenance costs in institutional/commercial buildings are lower than any other space conditioning option.[34] In the residential sector, GHP can reduce space-conditioning costs compared with conventional heating and cooling options, and it can stabilize both conditioning costs and increase security of supply. [35] Low-grade thermal heat is less expensive per delivered energy unit than high-grade electricity, and the technology can meet heating and cooling demand with a more appropriate source of energy. In addition, GHP can complement utility demand curves and allow peak loads to be reduced by serving as a base-load supply. By eliminating the need for natural gas for space and water heating, fossil fuel reserves can be diverted to applications with a higher commercial value such as centralized electricity generation, production of hydrogen or for the export market.

### ENVIRONMENTAL

Compared with electric heating and cooling, GHP can reduce greenhouse gas emissions by up to 75% (depending on the fuel used for generation, when displacing carbon-based fuels the reductions are at the highest level).

### DISTRIBUTED RESOURCE

By reducing the need for high-capacity transmission towers and reducing congestion on the grid, geothermal energy works well in non-urban areas that lack a physical connection to a natural gas pipeline.

### DESIGN

GHP allows removal of roof-top chillers and boiling towers on institutional/commercial buildings, thereby reducing design constraints and allowing architects to increase the aesthetic appeal of a building. Once installed, both exterior and interior sections are invisible, eliminating any opposition to the technology on the basis of aesthetics.[36] The use of decentralized heat pumps minimizes the space required for a mechanical room and increases the percentage of usable space in a building. The technology is also well adapted for use in a 'net zero energy' building (for more details about net zero energy buildings see the solar power chapter).

### DURABILITY & SAFETY

Locating electro-mechanical components inside the building will minimize degradation from exposure to harsh weather conditions, while a buried loop experiences minimal degradation. The absence of exposed equipment reduces the risk of intentional or accidental damage, and the lack of combustion eliminates the need for on-site fuel storage and associated risk of explosion. The relatively stable run times of GHP reduces start-up pressures and other negative impacts on system life.

### COMFORT

The CSA standard requires acoustic insulation to ensure that there is virtually no noise from a system, and the absence of setback thermostats avoids the need for temperature reductions at night. The higher airflow of low-temperature air increases occupant comfort by reducing draughts, and GHP provides greater control over interior humidity and eliminates concerns over indoor air quality.

## 1.5 EMPLOYMENT

Currently, there are less than 15 companies in Canada involved exclusively in GHP. The balance includes HVAC (heating, ventilation, and air conditioning) companies that offer the technology as an option to conventional heating and cooling equipment. Of the 15, five are manufacturers or distributors, three are design firms and seven are installing contractor companies, with a total employment of 35 people.[37] Also, the equivalent of 50 person-years exist among 'part-time' contractors.[38]

Under the three-year Ontario Hydro program that resulted in the installation of 6,750 GHP units, the total number of registered contractors during that period was less than 300, of which half would have been involved on a 'full-time' basis for the duration of the program. At peak, it is estimated that each registered contractor had assistance from four additional workers (drillers, backhoe operators, etc).

Manitoba Hydro concludes that each 1,000 GHP residential installations result in $15 million in construction-related activity and over 150 jobs.[39] Extrapolating these job creation figures to Ontario, where 125,000 GHP home systems could be installed, results in 18,750 jobs by 2007. By 2020, the installation of 341,000 GHP systems could result in up to 51,150 jobs.

These estimates provide a good general indication of the employment potential of this technology in Ontario. It is emphasized that a follow-up study is required to determine more precisely the economic co-benefits of GHP for the province.

### 1.6 ECONOMIC DEVELOPMENT

The majority of GHP cost is the labour to install the loop, which maximizes the local benefits of each installation (unlike natural gas where the bulk of the economic activity is transferred outside of the province). In a residential system, three-quarters of the total pre-tax price is allocated to loop configuration, design, trenching, fusing, purging, backfilling and permits (the polyethylene pipe is the only 'hard cost'), with the balance of cost for all interior components (hardware, wiring, distribution, etc). In institutional/commercial buildings the exterior portion is approximately two-thirds of total cost, which reflects the economies of scale on loop installation and the higher relative number of heat pumps. These averages exclude any retrofit work.

All labour is assumed to be local and, when combined with up to one-third of equipment costs (distributor and dealer markups, components manufactured in Canada, etc), means that 80% to 85% of the total system cost is classified as 'local content'. The level would be higher for domestically-manufactured heat pumps, which currently comprise less than 10% of sales. Loop trenching requires a backhoe operator (or a qualified well driller for vertical loops), while a trained contractor can fuse the pipe. Excluding design and supervision, only general skills are required for a residential installation.

Under the above scenario, an average $20,000 residential system would contribute $16,000 to $17,000 to the local economy (excluding $3,000 in PST/GST). The Ontario budget tabled in May 2004 announced the intention to remove GHP from retail sales tax, to place it on an equal footing with solar thermal systems, which were exempted in 2003.

## 2. Ontario's GHP resource

Eighty percent of Ontario's population lives in the urban band along the Great Lakes, and almost half reside in the Golden Horseshoe. According to Statistics Canada, the province has one of the highest-growing populations in Canada, and the number of households is forecast to grow from 4.2 million in 1991 to 5.6 million by 2016.[40]

End use applications for thermal space heating, space cooling and water heating constitute 52%, 21% and 3.4% (respectively) of residential and 48.6%, 5.3% and 10.1% of commercial energy consumption in Ontario.[41] This total of 720 PJ can be met by GHP (representing 38% of the national total of 1,906 PJ consumed in the same end use applications).[42]

The environmental impact in the residential sector (excluding consumption of electricity) was 14.1 megatonnes of greenhouse gas emissions from space heating and 4.4 MT from water heating in the residential sector, 10.9 MT from space heating, 1.2 MT from water heating, and 0.4 MT from space cooling in the institutional/commercial buildings market.[43]

In Ontario in 2003, there were 85,180 residential housing starts, of which 70,250 were in the top ten Census Metropolitan Areas (CMA) and 14,900 elsewhere in the province.[44]

There are few technical constraints to the adoption of GHP in new buildings, either in the residential or institutional/commercial buildings sector. It is a fully 'dispatchable' distributed resource that can provide energy at any time of day, and performance can be enhanced with thermal storage.[45] The constraints in the retrofit market relate to the need for renovations to accommodate a loop or a distribution system.

The CSA standard stipulates separation distances within loop designs to ensure that one pipe does not 'steal' heat from the collection area of a neighbouring pipe, and it provides guidance to avoid septic tanks, utility line setbacks, and other parameters to ensure proper design and installation in residential or commercial sites.

While a GHP unit can be installed almost anywhere in a building, it is not effective to install a loop under an existing building or under existing infrastructure such as roads. However, it is very practical to install loops prior to construction of buildings or roads. Installation and pumping costs, as well as thermal losses, become significant when a loop is installed more than 250 m from the load, with GHP systems designed to be as close as possible to the load centre.

Due to difficulties in assessing conversion costs for the existing stock of 4.4 million dwellings in Ontario, this paper examines the impact of installing GHP only in new construction, under the 'advanced' scenario. It will assume an average of 75,000 new housing starts a year, of which 80% are located in metropolitan areas (i.e.: 60,000 a year

in metropolitan and 15,000 in 'rural' areas).[46] It also assumes a total of 1% of existing stock will convert to GHP over the same period, for a total of 44,000 'basic' units.

Under this scenario, the impact of installing GHP in 10% of metropolitan units and 50% of rural units is illustrated below:

**TABLE 3**

Residential Housing Starts (single-family detached homes only)

| | Installations per year | Consumption (000 kWh/year) | Energy savings (000 kWh/year) |
|---|---|---|---|
| Metropolitan | 6,000 | 36,600 | 100,800 |
| Rural | 7,500 | 45,750 | 126,000 |
| **Existing stock** | **44,000** | **550,000** | **787,600** |

Note
It is assumed that most metropolitan homes are heated by natural gas but all are cooled through electric air conditioners; it is also assumed that GHP could satisfy 10% of that market. It is assumed that much of the rural homes are not on the gas line and are heated with electricity, oil or propane and that GHP could satisfy 50% of that market. It is also assumed that as homes become more thermally efficient, heating load drops, but air conditioning load continues to climb.

By 2010, 125,000 homes with GHP could be installed in Ontario and their total electrical consumption for space conditioning and water heating would be 1,044,100 MWh. However, these buildings would save the thermal equivalent of 2,148,400 MWh each year (or 7.7 PJ). This projection is for residential space conditioning only, and does not reflect the reduction for domestic hot water or the impact from large-scale institutional/commercial building installations.

Using the same parameters, by 2020 Ontario could have 341,000 residences with GHPs, and their total consumption of electricity for space conditioning load would be 2,361,700 MWh. However, these facilities would save the thermal equivalent of 5,777,200 MWh a year (or 20.8 PJ).

Based on the estimate of 3,064 $m^2$ of annual consumption of natural gas, the displacement of gas combustion in 2010 would be 383 million cubic metres ($m^3$) and more than 1 billion $m^3$ by 2020.[47]

### 2.1 GROWTH QUICKENS IN NEW MARKETS

There are no empirical models to suggest how retail installed prices would be affected by volume installations, but the installation cost estimates provided by Manitoba Hydro (which has the highest per-capita installation rate in the country) indicates that a hypothetical total of $20,000 could decline to $17,000 (15%) with increased demand. Anecdotal comments from contractors estimate that, if sales volume doubled, cost reductions could be:

– 20% for components (heat pump, transfer fluid, pipe) due to volume purchase;
– 10% for design due to economies of scale and increased speed;
– 25% for installation (horizontal or vertical) due to economies of scale, reduced travel time, improved rates from drillers, etc.

It is possible that average residential system costs could drop by 20% to 25% under an increased volume scenario.

A comprehensive report that analyzed Canadian installations included a sensitivity analysis to assess the impact of rising natural gas and oil prices on the relative cost of GHP, and found that the latter improves its price advantage against conventional space conditioning technologies.[48]

## 3. Mechanisms to encourage GHP

A number of broad-based fiscal, monetary and regulatory measures are required to advance the understanding and acceptance of GHP in Ontario, in both the residential and institutional/commercial building sectors.

Among these, the province must work with federal government officials to develop a method to quantify the energy contribution from GHP in order to enhance its perceived value to the marketplace. It must also request an extension of the eligibility for Class 43.1 accelerated capital cost allowance for GHP installations, and work with federal agencies to facilitate a process under which GHG emission reductions from GHP can be aggregated into a trading pool for credit under the Kyoto Protocol.[49]

The impact of promoting a non-commercial energy source was evident in 1999, when the U.S. Energy Information Administration was estimating total consumption of renewable energies in that country at 3.9 quadrillion ($10^{15}$) British Thermal Units (Btu), mainly from hydro, geothermal electric, wind, solar PV and biomass at electric utilities. An analysis by the Canadian Association for Renewable Energies noted that the data did not include 2.6 quadrillion from GHP, wood stoves, solar water heaters and off-grid wind turbines, solar panels and small hydro facilities, and its intervention prompted EIA to amend its reporting to increase the contribution of renewables by two-thirds.[50] There is

reason to believe that the energy contribution from other renewable heat technologies (specifically GHP) also suffers from significant under-estimation in Canada due to its lack of market quantification.

The province must make every effort, in consultation with the federal government and industry, to define the parameters for GHP (and all renewable heat technologies) to provide a context within renewable energy supply and demand.

It is critical for the province to compile data on the past, present and future installed capacity for the technology in various end use applications, so the economic and environmental impacts can be quantified. In addition, the province must undertake a 'level playing field' assessment of policies pertaining to GHP, similar to the 1992 study by Finance Canada that concluded there was economic discrimination against green heat technologies and which led to the creation of the federal Renewable Energy Deployment Initiative (REDI) in an effort to reduce that discrimination.[51]

GHP is used heavily in Europe for district heating and cooling systems, in both residential and institutional/commercial buildings. District energy is still a low priority in Canada, but this promising niche should be developed.

A study of the barriers to understanding and acceptance of green heat technologies in general, and GHP in particular, must be undertaken to identify the market niches where this viable technology is most economically and environmentally beneficial.

In addition, any measures that would facilitate the future consideration and adoption of GHP should be considered (e.g. require that new building projects conduct and file a soil conductivity analysis to identify high-efficiency soils for future conversions, pre-install ground loops in residential subdivisions to allow future conversions).

The Ontario Building Code should also be amended to require that new home construction accommodate future installation of GHP, including adequate space for oversized heating ducts, adequate location of new homes to allow future installation of ground loops, and reliance on CSA C448 for the design and installation of all systems.

## 4. Recommendations

To achieve the many benefits that GHP development can generate for the province the Government of Ontario should:

i. Use its procurement ability to source 20% of the space conditioning and water-heating load in all facilities under its control from GHP by 2010, as part of a green heat procurement program. This level should rise to 50% by 2025 and is aimed at effecting a market transformation in the institutional/commercial building sector. In order to achieve this level, it is expected that almost all new public buildings would incorporate GHP technology, combined with the highest penetration possible for cost-effective retrofits when those buildings need upgrading or refurbishment.

ii. Enact legislation to require that 20% of space conditioning and water heating in all municipal facilities come from GHP by 2010 and 50% by 2025. Municipal officials would identify the most appropriate facilities assuming that new public buildings would receive priority attention for GHP installation.

iii. Direct the Ontario Energy Board to require all distributors of space conditioning and water heating fuels to source 10% of their sales within Census Metropolitan Areas and 50% in all other areas from GHP by 2010; 50% and 75% respectively by 2025. Introduction of a 'system benefit charge' on all thermal energy customers could offset any first-cost premium.

iv. As part of Kyoto commitments to reduce greenhouse gas emissions, collaborate with the federal government to establish a revolving loan system for the financing of ten-year interest-free loans for the installation of GHP, both for interior components and exterior loop, in both residential and institutional/commercial buildings. This measure is estimated at $1,000 per year (residential) and should be covered by a special 'green fund' that provides a declining level of support and a clear exit strategy.

v. Enact regulations to highlight GHP as the default space conditioning technology in regions not served by natural gas pipeline to minimize the need to install distribution infrastructure for fossil fuels.

## 5. Conclusions

Every effort should be made to exploit GHP and other renewable heat technologies on both economic and environmental bases.

Without a high-level commitment from regulators that GHP is a preferred option for space conditioning, and without an assured minimal market, the technology will continue to experience market disadvantages when competing with subsidized conventional energy options.

Finally, the provincial government needs to help the GHP industry complete existing plans for training, accreditation and warranty coverage of GHP installations in both residential and institutional/commercial buildings sectors to ensure the sustainable development of this promising renewable energy option.

## GHP Appendix

A) The need for space conditioning is determined by Heating Degree Days (HDD) and Cooling Degree Days (CDD) at any location, based on a balance point of 18° and insulation levels of the building and occupant factors.
   – Toronto (43.7 N latitude) has 3,644 HDD and 346 CDD (Environment Canada 150-year average). Design is –17.1° for heating and 28.8° for cooling.
   – Ottawa (45.3 N) has 4,606 HDD and 242 CDD. Design is –21.4° for heating and 27.6° for cooling.

B) Four scenarios:
   1) 185 $m^2$ (2,000 $ft^2$) home in Toronto, medium insulation, 2-storey, full basement, air conditioning, minimal efficiency (2.8 COP) heat pump, standard spacing of horizontal loop configuration, heavy damp soil.
   2) same home in Ottawa
   3) 9,290 $m^2$ (100,000 $ft^2$) commercial building in Toronto, medium insulation, five-storey, standard windows, daytime occupancy, moderate equipment and lights, minimal efficiency heat pump, vertical boreholes, standard loop configuration, heavy damp soil.
   4) same building in Ottawa.

**RETSCREEN OUTPUT:**

1) Toronto residence:
–Design heat load of 8.8 kW and 9.9 kW for cooling.
–GHP requires 255 m pipe in 128 m trench, footprint of 311 $m^2$.
–System consumes 6.9 MWh of electricity for heating and 5.0 MWh for cooling loads, to allow GHP to deliver 15.9 MWh and 13.6 MWh equivalent heating/cooling.

2) Ottawa residence:
   – Design heat load is 9.9 kW and 9.4 kW cooling.
   – GHP requires 306 m pipe in 153 m trench, footprint of 373 $m^2$.
   – System consumes 8.7 MWh heating and 20.1 MWh cooling, GHP delivers 4.3 MWh and 11.0 MWh.

3) Toronto commercial:
   – Design heat load is 212.2 kW and 599.5 kW cooling load.
   – GHP requires 15,341 m borehole, footprint of 4,466 $m^2$.
   – System consumes 208.0 MWh heating and 234.3 MWh cooling, while GHP delivers 448.0 MWh and 838.3 MWh.

4) Ottawa commercial:
   – Design heat load is 234.9 kW and 574.2 kW cooling load.
   – GHP requires 14,051 m borehole, footprint of 4,086 $m^2$.
   – System consumes 232.8 MWh heating and 194.7 MWh cooling, GHP delivers 515.2 MWh and 695.2 MWh.

The following parameters were changed in the RETScreen model:

- Residence: increase insulation levels to high from medium, upgrade loops to vertical boreholes from horizontal, upgrade heat pump COP to 4.0 from 2.8, upgrade loop to very compact from standard, upgrade soil conductivity to light rock from damp heavy.
- Commercial: increase insulation levels to high, COP 4.0 heat pumps, loop bed was very compact, usage of equipment and lights was reduced to light from moderate, and soil conductivity was light rock.

1) Advanced Toronto residence:
   – Heat load drops to 5.8 kW and 9.3 kW for cooling.
   – GHP requires 92 m borehole, footprint of 5 $m^2$.
   – System consumes 2.5 MWh heating and 8.1 MWh cooling, GHP delivers 3.5 MWh and 15.0 MWh from earth.

2) Advanced Ottawa residence:
   – Heat load is 6.6 kW and 8.9 kW for cooling.
   – GHP requires 174 m borehole, footprint of 5 $m^2$.
   – System consumes 3.1 MWh for heating and 10.4 MWh for cooling, while GHP delivers 3.1 MWh and 12.3 MWh.

3) Advanced Toronto commercial:
   – Heat load is 262.3 kW and 458.0 kW cooling load.
   – GHP requires 7,180.7 m borehole, footprint of 332 $m^2$.
   – System consumes 157.0 MWh for heating and 109.0 MWh for cooling, while GHP delivers 461.6 MWh and 570.3 MWh.

4) Advanced Ottawa commercial:
   – Heat load is 3.5.4 kW and 433.1 kW cooling load.
   – GHP requires 9,470 m borehole, footprint of 439 $m^2$.
   – System consumes 185.2 MWh for heating and 88.9 MWh for cooling, while GHP delivers 567.7 MWh and 464.7 MWh.

The RETScreen models indicate that an 'advanced' residence that combines higher thermal building efficiency with superior GHP, will reduce space conditioning load compared with an 'average' residence by 23% (30 to 23) and by 17% (1,248 to 1,032) in an institutional/commercial building. This improvement in both the demand and the supply sides means that a GHP system would consume 50% less electricity (12 to 6) to deliver full space conditioning in a home and 38% less (435 to 270) in an institutional and commercial building.

The same residence was modeled in two northern centres for comparison:

- Thunder Bay (48.4 N): heating load was 11.7 kW (27.4 MWh) and 9.3 kW cooling (9.7 MWh), requiring 387 m of loop pipe in 193 m trench and a footprint of 472 $m^2$. System consumes 11.7 MWh to deliver 27.4 MWh from GHP, and consumes 4.0 MWh to deliver 9.7 MWh from GHP cooling.
- Big Trout Lake (53.8 N): heating load was 13.2 kW (35.1 MWh) and 8.2 kW cooling (5.7 MWh), requiring 463 m of pipe in 231 m trench and footprint of 564 $m^2$. System consumes 14.8 MWh to deliver 35.1 MWh GHP heating, and consumes 2.9 MWh to deliver 5.7 MWh in GHP cooling.

## GEOTHERMAL ENERGY IS HOT IN MANITOBA

Manitoba is leading Canada in total installations of GHPs, representing 30 percent of total new Canadian installations last year. Geothermal heat pumps are one of the most energy efficient, environmentally-responsible home heating and cooling systems available. Heat pump technology works by moving heat out of or back into the earth. Geothermal units are connected to the earth through pipe buried under your lawn or landscaped area.

Manitoba Hydro currently offers home-owners a loan of up to $15,000 to install a geothermal heat pump when building a new home or replacing an old heating system. Manitoba Hydro, working closely with the International Ground Source Heat Pump Association, has sponsored installer certification courses in order to build the market infrastructure in Manitoba. In fact, the number of IGSHPA certified installers in Manitoba has increased by 130% over the last year.

One of the initiatives currently being explored by the Province of Manitoba, the City of Winnipeg and Manitoba Hydro is the potential for a 100 percent geothermal new home development in Winnipeg – Waverley West; which if implemented would be the largest geothermal housing development in Canada.

The energy savings achieved by install-ing a geothermal heat pump system are considerable. Manitoba Hydro has found that geothermal heat pumps can reduce annual heating bills by $400 to $800 compared to natural gas; by $600 compared to electric heating; and by $700 to $1,800 compared to heating oil and propane based on rates as of May 1, 2004.

According to Manitoba Hydro, each geothermal home reduces carbon dioxide emissions by 9 tonnes and each commercial unit by 34 tonnes. Each 1,000 residential installations results in $15 million in construction-related activity and over 150 jobs

### TORONTO OFFICE TOWERS COOLED BY LAKE ONTARIO

More than 100 office towers in downtown Toronto are using an alternative source of air conditioning – cold water from Lake Ontario.

Enwave District Heating is bringing "deep water cooling" to Toronto, making it the largest lake source cooling system in the world. The deep lake cooling project takes cold water from Lake Ontario and draws it into a downtown pumping station. From there, through a series of heat transfers, the cold lake water is used instead of electricity to air condition buildings along the Enwave network.

Three pipes extend five kilometres out into Lake Ontario, reaching a depth of 83 metres below the lake surface. The pipes draw near-freezing water to cool downtown office buildings. The water is then transferred to the city's water treatment system and becomes safe drinking water.

The Air Canada Centre, the Metro Convention Centre, the Steam Whistle Brewing Company, the Royal Bank Tower and the offices at 1 University Ave. are just some of the buildings using deep lake water-cooling.

This cooling process requires less energy and reduces electricity use by up to 75 percent less than conventional cooling. According to Enwave, emissions from coal-fired electricity will be reduced by more than 40,000 tonnes. The lake water-cooling system eliminates the need for conventional, on-site mechanical air conditioners that consume electricity and rely on CFC refrigerants. The project is expected to save 30 million kWh a year and free 35 megawatts of capacity from the provincial grid.

## Vancouver complex is hot stuff

Geothermal energy heats and cools thousands of buildings worldwide, including a large apartment and business complex in the heart of Vancouver, B.C.

The mixed-use, four-storey building doesn't use fossil fuels for heating or cooling. Geothermal energy provides heat and hot water for the complex, which includes a combination of retail stores, offices and apartments.

During the complex's construction, builders drilled 46 holes 100 metres into the ground. Inside the holes run a series of closed-loop plastic pipes filled with water. The water flows through the pipes, absorbing heat from the earth. The warm liquid is piped to a heat pump in the building. The pump releases the heat, which is circulated as warm air by electric fans. In the summer, the process is reversed, with the system pulling heat out of the building and distributing it back into the earth.

Initial costs to install the geothermal energy system were higher, but it paid for itself after just three years. The system is highly efficient. For every watt of electricity used, the system provides three to four watts of heating or cooling power. That reduces operating costs by 50 to 75 percent over conventional systems. Other cost savings come from maintenance of the simple system, which has fewer mechanical components.

### GEOTHERMAL CHAPTER NOTES

1 See Union of the Electricity Industry and International Union for Electricity Applications. (2004). *Electricity for more Efficiency: Electric Technologies & their Energy Savings Potential*. Brussels: EURELECTRIC. Available at www.eurelectric.org/PublicDoc.asp?ID=27573 and also Caneta Research. (1999). *Global Warming Impacts of Ground-Source Heat Pumps Compared to other Heating Cooling Systems*. Ottawa: NRCan Renewable & Electrical Energy Division. Available at www.geo-exchange.ca/en/newsroom_reports.html

2 This chapter will not address air-source heat pumps (which extract latent heat from ambient air and offer limited capacity when outside air temperatures are below freezing), nor internal loop heat pumps (which employ the same compressor technology as GHPGHPGHP but rely on roof-top chillers or boiling towers as their heat source / heat sink), nor direct-use geothermal (such as hot springs in Banff or Iceland), nor the generation of electricity from deep geothermal boreholes (such as the South Meagher site in B.C.). The last two technologies have no available resource in Ontario.

3 Illustrations for five configurations are available at http://www.canren.gc.ca/school/index.asp?CaId=180&PgId=1001

4 A general industry guideline is that a body of water with 2,000-$m^2$ surface area and a depth of 3 m hold sufficient thermal heat for an average-sized home.

5 The minimum COP allowed in Canada is 2.8, with most models claiming a COP of 3.5 to 4.0 and, in some hybrid applications, reaching a non-certified COP of 7.0. Performance is rated under CSA 13256 (approved in 1998) based on an ISO standard, while models rated under the earlier CSA standard C446 or the U.S. ARI equivalents are accepted in Ontario

6 Each building (residential or institutional and commercial) must calculate its heat loss prior to determining its conditioning load, and the seven-step soil classification can have a 4:1 differential on the amount of loop required for the same building envelope due to soil conductivity (which would increase the cost of loop installation accordingly).

7 See Earth Energy Society of Canada (2001) at http://www.earthenergy.ca/saving.html

8 See Office of Energy Efficiency. (2000). *Home Heating & Cooling: A Consumer's Guide*. Ottawa: NRCan. Available at: http://oee.nrcan.gc.ca/publications/infosource/pub/home/M91-2-41-2002E.pdf

9 See Manitoba Hydro's price comparisons http://www.hydro.mb.ca/saving_with_ps/home_heating_comparisons.pdf

10 Based on retail power rates of 5.16¢/kWh and a seasonal COP of 2.5.

11 Marbek Resource Consultants (1999). *Ground Source Heat Pump Market Development Strategy*. Ottawa: NRCan.

12 See Office of Energy Efficiency. (2000) op. cit. note 8.

13 Calculation details available from Earth Energy Society of Canada (www.EarthEnergy.ca)

[14] See page A50 of budget paper titled "The Economy" in Manitoba Finance. (2004).The 2004 Manitoba Budget Papers. Available at www.gov.mb.ca/finance/budget04/papers

[15] See Information Survival Kit for the Prospective Geothermal Heat Pump Owner, published by Geo-Heat Center, April 2004, viewable at http://geoheat.oit.edu/ghp/faq/faq02.htm Fuel costs are quoted at US$0.07/kWh for electricity, $1.05/gallon for fuel oil, $1.20/gallon for propane, $0.60/therm for natural gas, with a house in a "moderately cold climate." Savings do not include DHW heating and space cooling.

[16] IEA. (2002). *Closed Loop Ground-Coupled Heat Pumps: Informative Fact Sheet.* Available at: http://www.heatpumpcentre.org/publ/HPCOrder/ViewDocument.aspx?RapportId=14

[17] See IEA Heat Pump Centre Newsletter (volume 22, number 2, 2004). Available at: http://www.heatpumpcentre.org/Home/Newsletter_N22.02.pdf

[18] The publication, Environmental Protection Agency. (1993). *Space Conditioning: The Next Frontier,* analyzed several space conditioning technologies (GHP technologies, air-source technologies, oil, and natural gas systems) in six regions of the U.S. and identified GHP as the top choice for heating and cooling in all locations, with the lowest annual operating costs and lowest annualized costs in all locations (except Portland), and best option for GHG mitigation.

[19] 'Low temperature geothermal' can refer to either GHP or direct use geothermal, but not to generating capacity.

[20] Since June 2002, the Canadian Association for Renewable Energies has tried to obtain data from the federal government on renewable energy in Canada; see http://renewables.ca/atip.html. Access to Information requests indicate that no data are available at the federal level.

[21] Select Committee on Alternative Fuel Sources, Legislative Assembly of Ontario, Final Report, 3rd Session, 37th Parliament, page 8. There are no data provided on GHP capacity or forecasts.

[22] Between 1995 and 2003, there were at least four separate attempts to compile data from manufacturers, including the use of double-blind surveys. The refusal to provide data is attributed to competitive issues between the small numbers of manufacturers operating in Canada.

[23] The program involved a $2,000 rebate for homes that installed a certified GHP unit from a registered contractor trained by the CEEA; the rebate was not provided to homeowners who could access natural gas service and was intended to stem the customer base that was converting to natural gas for heating while leaving the utility with plug load. Termination of the rebate was perceived by many consumers as a failure of the technology, and sales in Ontario declined for a number of years.

[24] RETScreen was developed in 1998 by NRCan's CANMET Energy Diversification Research Laboratory to evaluate energy performance, cost and financial viability of implementing renewable energy technologies. As of March 2004, NRCan says there are 41,500 users in 196 countries. See www.RETScreen.net

[25] Energy required to heat and cool the facility (excluding water heating) over a one-year period.

[26] Electricity required for one year to operate the GHP system in heating and cooling modes, to provide the same level of heating and cooling.

[27] Total electricity for heating and cooling over one year, averaged between Toronto and Ottawa.

[28] Comprehensive Energy Use Database, 2002, published by NRCan, viewable at http://oee.nrcan.gc.ca/neud/dpa/comprehensive_tables/index.cfm?text=N&printview=N

[29] See GHP Appendix: 12,500 MWh versus 30,300 MWh.

[30] See GHP Appendix: 6,100 MWh versus 22,900 MWh.

[31] See GHP Appendix: 6,100 MWh versus 30,300 MWh.

[32] Using estimates based on Enbridge Gas Distribution billing.

[33] EPA (1993) op.cit. note 19 Marbek (1999) op.cit note 11.

[34] Marbek (1999) op.cit. note 11.

[35] Based on a COP of 4.0.

[36] See http://IMBY.org; In My Back Yard.

[37] Estimate compiled by Earth Energy Society of Canada.

[38] Ibid.

[39] Martin Cloutier, Manitoba Hydro (September 2004), personal communication.

[40] Ontario Ministry of Finance, Population Projections.

[41] Comprehensive Energy Use Database (2002) NRCan, http://oee.nrcan.gc.ca/neud/dpa/comprehensive_tables/index.cfm?text=N&printview=N

[42] Comprehensive Energy Use Database (2002) NRCan, http://oee.nrcan.gc.ca/neud/dpa/comprehensive_tables/index.cfm?text=N&printview=N

[43] Ibid.

[44] See Housing Market Indicators, Ontario, 1990–2002 in Canadian Mortgage and Housing Corporation. (2003). Canadian Housing Observer. Ottawa: CMHC. Available at www.cmhc-schl.gc.ca/en/cahoob/index.cfm

[45] Energy is provided on demand; it is not conditional on external storage or reliant on weather patterns.

[46] CMHC (2003) op.cit note 44.

[47] Enbridge op. cit. note 32.

[48] Marbek (1999) op. cit. note 11. The report analyzed 135 scenarios in 12 building segments (elementary school, high school, seniors complex, high-tech facility, curling rink, hockey arena, mid-size hotel, motel, suburban office, high-rise condominium, retail strip mall, residential subdivision) at sites in Toronto, Montreal, Winnipeg, Vancouver, Moncton and Kamloops.

[49] A process to aggregate GHG credits from residential GHP systems was developed by the Earth Energy Society of Canada in 2002.

[50] For details see Environmental News Network. (July 13, 1999). DOE renewable energy reports questioned. Available online at www.enn.com/news/enn-stories/1999/07/071399/renew_4310.asp

[51] For details about REDI see http://www.canren.gc.ca/programs/

# 6 Solar Energy

## Summary


Solar energy can be used in Ontario to generate pollution-free electricity and heat for residential, institutional, industrial, and commercial applications.

The most promising solar technologies in the short term are those that capture the sun's rays to heat indoor spaces or water, thereby replacing fossil fuels or nuclear energy that would have been used in these applications. These relatively simple and low-maintenance technologies can provide elegant, clean solutions to some of our energy needs.

Solar energy currently provides 8% of the average Canadian home's heating requirements (in the form of sunlight entering through windows). This proportion of 'solar thermal' energy (converting sunlight into heat) could be easily increased to 22% with minor changes in community planning, building design, and higher standards.

Solar thermal energy can also provide 40–50% of residential hot water heating and 15% of commercial hot water heating requirements at a cost below the current price of electrically heating water (at the equivalent of 8.4 cents per kilowatt hour), while 39% of pools can be heated using solar thermal panels. Solar walls in new construction can replace other energy sources for space heating at the equivalent of 2 cents per kWh.

Achieving the province's solar thermal potential will require a mix of regulatory changes (e.g. building codes, zoning by-laws), marketing support programs to raise public awareness and inform builders on solar thermal options, and tax changes to actively promote solar thermal technologies.

Solar photovoltaic (PV) systems, which convert sunlight into electricity, are currently less cost-competitive but have the advantage of generating clean, reliable power on site at the time of peak usage. It also has no moving parts so requires little maintenance and the fuel is free.

By implementing the policy measures proposed in this chapter, Ontario could capture one-half of the technical potential for solar thermal and photovoltaic technologies, providing as much energy in 2025 as coal did in 1999.

Japan and Germany are two countries with relatively modest solar resources but have nevertheless quickly become world leaders in solar photovoltaic (PV) technology.

The experience of these leaders clearly illustrate that strong solar markets can be quickly established if supportive policy measures that focus on the use of gradually declining subsidies, strong government R&D, and active market penetration are implemented.

Germany has become a world leader in solar PV through the enactment of its renewable energy mechanisms (REMs) law that guarantees stable payment for each kWh of PV-generated electricity, and grid access for PV owners.

Southern Ontario has some of the best solar potential in Canada and the province can support a significant expansion of PV and solar thermal technologies by implementing REMs and other key supporting initiatives that address existing financial, technical, and educational barriers.

The solar industry worldwide has been growing at double-digit rates, and Ontario is in a unique position of benefiting from this well-established trend. By supporting its burgeoning solar industry, Ontario can obtain reliable energy (without fuel costs), a cleaner environment, and strong job creation.

This chapter identifies the potential applications for solar technology in Ontario; it also reviews recent developments and policies in other countries, and

proposes a series of policy initiatives that would greatly increase the contribution of solar energy in Ontario over the next 15 years.

## 1. Background on solar energy

While there have been assessments on the potential of individual solar technologies carried out in the past (mainly in the 1980s and early 1990s), there has not been a comprehensive assessment of solar potential in Canada or its provinces.[1] In part this is due to a flawed, but widely held, assumption that solar has low potential for making a significant impact on the energy needs of Canada. In addition, the fact that the three main solar technologies (photovoltaic, thermal, and passive) include a variety of niche markets makes an overall assessment difficult.

Solar energy is almost exclusively an on-site generator of energy. As such, its implementation represents a major paradigm shift away from central power plant generation.

While solar energy is often considered an option for the future, right now 8% of the average Canadian home's heating requirements are supplied by the solar energy that flows naturally into homes through south facing windows. By proper community planning and only minor alterations in new house design and construction this share could easily be increased.

While there are many widespread misunderstandings surrounding solar energy, one of the most prevalent is that Ontario does not receive sufficient sunlight to provide a practical power source. In reality, Ontario has a greater solar resource than many of the current solar leaders (Japan and Germany). Toronto, in fact, has a better summer solar resource than the city of Miami, Florida.

Solar energy can be used to generate electricity using solar photovoltaic (PV) systems and can also be harnessed for thermal applications (e.g. space and water heating, which displaces electricity and/or fossil fuels currently used for those purposes).

PV systems are currently widely used to provide power in remote areas (e.g. for telecommunications systems, navigational signals, off-grid applications), and their use for grid-connected electricity generation is growing rapidly in a number of jurisdictions such as: Germany, Japan, and the state of California. As the price of PV systems drop, the potential to meet Ontario's electricity needs will be significant.

Solar thermal applications can be used to satisfy space conditioning and hot water needs. For example, building

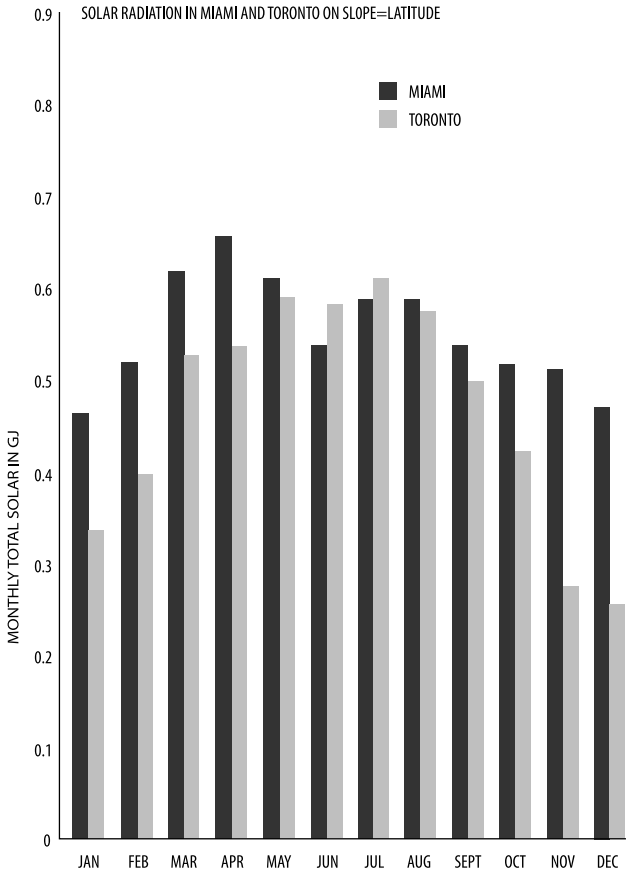



FIGURE 1 Solar Radiation in Miami and Toronto[2]

owners in Ontario can reduce their hot water energy bills by 40–50%, by installing a solar water heater.[3] Solar hot water systems can be installed in almost every kind of building, from a single suburban home to a condominium or apartment building. Plus, if the cost of a solar hot water system (SHW) is calculated over the life expectancy of the system (using the same methods that utilities employ to estimate the cost of the electricity they supply to consumers), then solar thermal is one of the cheapest ways to generate heat available today.

Commercial and industrial buildings can use cladding designed to collect the sun's heat for heating and cooling purposes with virtually no additional material costs. Buildings can also be designed with day lighting principles (thereby significantly reducing the need for artificial illumination and its associated electricity use). Roofing shingles and glass can be made of photovoltaic (PV) materials that generate electricity. Many of these solar systems can be used instead of existing construction materials and can contribute significantly to the entire lifetime energy needs of a building.

However, as a result of a pervasive and widespread focus on electricity generation, solar thermal systems are

often not considered when energy issues are discussed. Furthermore, solar thermal applications are also not generally addressed under discussions of energy conservation (in such cases they are often excluded because they are widely considered as a "generator of energy").

Although often overlooked, solar energy can be an important local energy solution in Ontario that can supply clean and reliable electricity and heat – without any fuel costs. Solar energy has an important role in reducing our dependency on polluting fossil fuels and unreliable nuclear energy.

## 1.1 WORLDWIDE SOLAR DEVELOPMENT

The world market for photovoltaic (PV) systems has been growing at 30% annually for the past five years.[4]

In 2003, production of PV cells and modules reached the highest-ever level at 744 MW, which represents a 32.4% increase over the 2002 production figure of 562 MW.[5]

In Japan, PV cell and module production increased 45% during 2003, and in Europe there was a 43% increase in PV production.[6]

The bulk of the 2003 PV production was used for grid-connected installations in the leading solar markets of Japan (200 MW) and Germany (120 MW).

Japan was a minor PV player in the early 1990s but through a combination of supportive policies and active public education, the country rose to become the world's largest producer and user in less than a decade. By relying on renewable energy mechanisms, low-interest loans, comprehensive education programs, rebates for grid-connected residential systems, and government procurement, Japan has now three times as much PV capacity as the entire United States.[7]

Germany's impressive success in wind power has also been replicated in its PV sector. Second only to Japan's PV market, Germany's PV installations have grown at an average annual rate of nearly 49% since 1992 and reached 417 MW of installed capacity, mostly on-grid, at the end of 2003.[8] Germany's PV success is the result of two key policies: a) feed-in laws that guarantee a fixed price for any power fed into the grid from a renewable source (referred here as renewable energy mechanisms), and b) a government initiative that provides low-interest loans to purchase PV systems (the '100,000 solar roofs programme').[9]

Japan and Germany are two countries that have modest solar resources but have nevertheless become world leaders in PV technology. Their success is based on the fact that they both share a long-term commitment to advancing renewable energy and have implemented effective and consistent policies focused on the use of gradually declining subsidies, strong government R&D, and active market penetration.

Canada is lagging significantly behind other industrialized nations in the deployment of PV. Canada has an installed PV capacity of 0.28 watts per capita, which is only 28% of the IEA average (1.0 watt per capita) and is considerably behind the world leaders of Japan (3.6 watts per capita) and Germany (2.4 watts per capita).[10] Figure 2 shows the 2001 installed PV capacity in a number of countries.

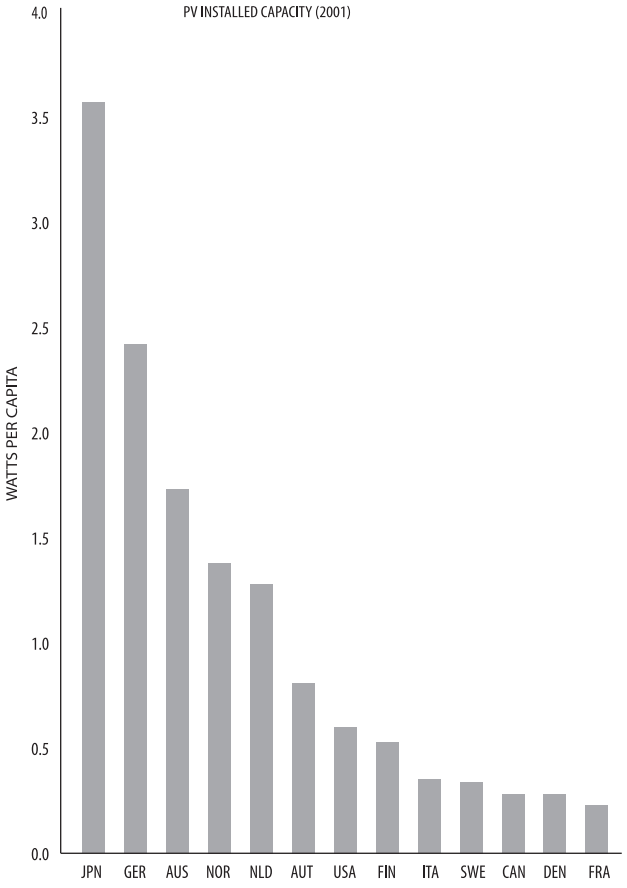



FIGURE 2 PV installed capacity (2001)

At the end of 2001 a total of 100 million square metres ($m^2$) of solar thermal collectors were installed in 26 IEA member countries, with about 71% of collectors in use for hot water and space heating, 28% for heating swimming pools, and 2% for drying agricultural products and space heating.[11]

Germany is the leading solar thermal market in Europe and in 2003 installed about 80,000 systems (720,000 $m^2$ of glazed collectors).[12] These systems are

currently promoted by the German government through a market incentive program that provides a subsidy of $180 per $m^2$ of collector surface area. However, the German government and industry are collaborating to replace this program with a new law that would provide a payment for every equivalent kWh of heat generated by renewable energies (this system is inspired by the REM currently in place for PV electricity generation).[13]

## 1.2 SOLAR ENERGY IS A RAPIDLY GROWING BUSINESS

The market for solar worldwide is expanding rapidly with impressive growth rates that are comparable to those of the personal computer and cell phone industries in the boom markets of the 1980–90s.[14] PV markets globally are now worth US $3.5 billion a year and are expected to grow to US $28 billion by 2012.

In Canada, solar markets are in a very early development stage and the current national PV market is more similar to those of low-income nations where the majority of installations (>95%) are for off-grid applications. The trend within industrialized nations is for an increasing proportion of PV sales (currently >80%) for grid-connected applications supported by market-enhancing government programs and proactive policies.

Natural Resources Canada (NRCan) has conducted an annual survey of the PV market in Canada since 1996, which shows annual double-digit growth. As the market is exceedingly small and diverse it is unlikely that the survey, with the limited resources dedicated to it, captures all sales in Canada. The need for accurate data will become more acute as the PV industry begins to expand rapidly into the grid-connected market. Unfortunately, the NRCan survey does not provide provincial breakdowns of sales. The Canadian Solar Industry Association (CanSIA) estimates Ontario's current installed capacity and annual sales as shown in the Table below.

**TABLE 1**

Estimated grid connected PV sales in Ontario in peak kW (KWp)

| | | Installed (2001) | Sales (2003) |
|---|---|---|---|
| Residential | Existing homes | 50 | 20 |
| | BIPV | 5 | 8 |
| Commercial | Rooftop | 50 | 20 |
| | BIPV | n/a | 20 |
| **Total** | | **105** | **68** |
| **Electricity** | **KWh** | **105,000** | |

Note.
The maximum possible output of a PV system operating under standard conditions is defined as its peak output, and is measured in watts or kilowatts and can be expressed as Wp (watt, peak) or kWp. BIPV = Building Integrated Photovoltaic.
PV generation calculation assumes that during peak sun hours a location can receive 1000 $W/m^2$ per hour and that the average in Canada is about 4 hours of peak sun per day (i.e. 4000 $Wh/m^2$/day); therefore, in a year (365 days) = 1460 hrs of peak sun (1,460,000 $Wh/m^2$/year). Thus, 1 watt of PV will produce about 1,460 watt-hours of energy. However, there are system and operational losses (e.g. inverters, batteries, and line loss), which will reduce the total that can be delivered to the grid to about 80% (hence we assume 1,168 watt-hours); therefore, we can express the final calculation as 1 watt of PV = 1000 watt hours (or 1 kWh) per year.

## 1.3 TECHNICAL CONSIDERATIONS

Solar technologies can be used to generate electricity, and also to satisfy residential and commercial heating, cooling, and illumination needs which helps to displace electricity and fossil fuels currently used for those purposes.

### PHOTOVOLTAIC

Electricity can be obtained by the use of photovoltaic (PV) systems, which rely on sunlight (photons) to generate an electric current.[15] This chapter considers four applications for grid-connected PV systems in Ontario: residential rooftop (existing homes); residential roof Building Integrated PV (BIPV) for new homes; commercial/institutional rooftop PV; and façade BIPV for new commercial buildings.

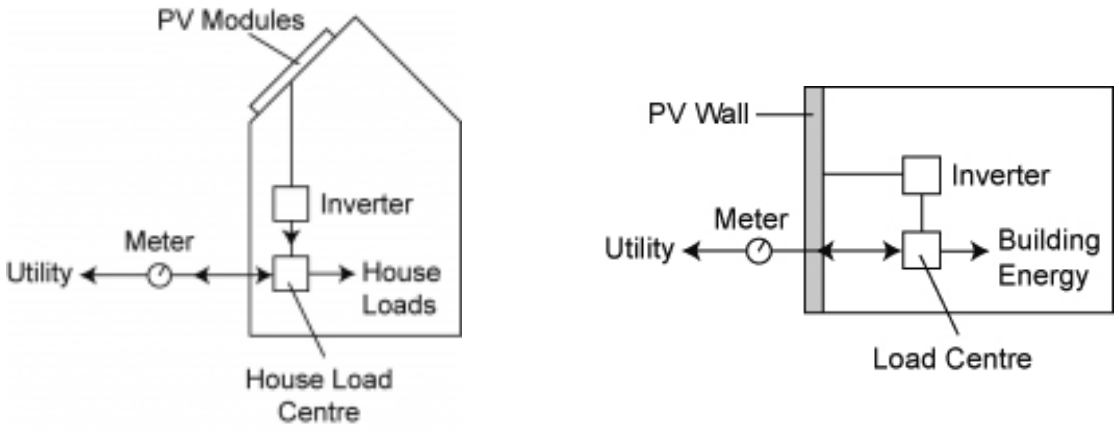



FIGURE 3 Rooftop PV and facade building integrated PV (BIPV)

### SOLAR AIR VENTILATION

Ontario is home to a company that is the world leader in manufacturing solar air ventilation (SAV) systems. However, most of the company's sales are international, and Ontario lags behind in the use of this technology when compared to other provinces and countries. SAV is a simple technology that can have great positive impacts on the space heating needs of commercial and industrial buildings. In existing buildings it can be retrofitted over existing walls, while in new construction SAV systems can actually take the place of a conventional wall. In terms of electricity, Solarwall (the trade name for solar air ventilation systems) can save about 556 kWh per square meter ($m^2$) per year in Ontario. In terms of peak capacity, each $m^2$ of Solarwall panels can generate the equivalent of over 500 watts or 0.5 kW of thermal energy when the sun is shining.

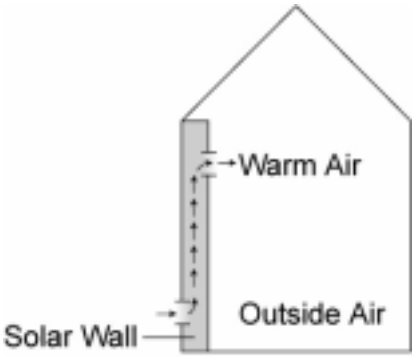



FIGURE 4 Solar air ventilation system (SAV)

Solar air ventilation systems are a competitive energy source now – providing clean energy at the equivalent of less than two cents per kWh if amortized over six years in new construction (where it replaces a metal wall). Installation costs are similar to the cost of a brick wall in new construction and thus the net cost for the energy it produces is zero.

### SOLAR WATER HEATING

Solar hot water collectors (like PV modules) have a capacity factor of 10–15% due to the fact that the sun doesn't shine all the time; i.e., a 1.5 kWp (1,500 Wp) solar thermal collector will deliver on average about 150 to 225 W of equivalent thermal power.

On an energy basis, the cost of solar thermal energy ranges between four to seven cents per kWh over the system's 20-year life expectancy. Solar hot water systems have a 20–25 year life expectancy during which the system does not require much attention (i.e. limited repairs and maintenance).[16]

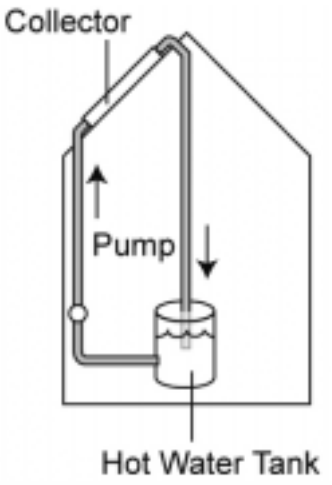



FIGURE 5 Solar domestic hot water (SDHW) system

Policy makers often ignore the issue of swimming pool heating as they consider it to be an insignificant market. However, an average heated outdoor residential swimming pool in Ontario will consume as much energy (40–50 GJ) over the summer swimming season as a typical house uses for space heating during an entire year. In Ontario there are an estimated 130,000 pools that are heated using natural gas and electricity – consuming 4.8 PJ (or the equivalent of 1,330 GWh) of non-renewable energy per year (2001).[17]

Solar water heating is relatively simple to integrate into a swimming pool's water filtering and circulation system. Pool water is pumped through the solar collectors using the pool's existing pump on sunny days while a bypass valve, operated manually or with a temperature-controlled solenoid valve, will bypass the solar collectors during the night or during cloudy weather.

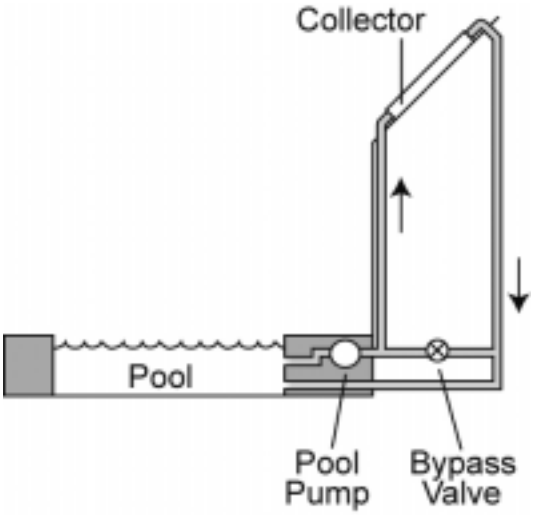



FIGURE 6 Solar pool heating system

### ON SITE SOLAR GENERATION: NET ZERO ENERGY HOME

Solar technologies are most effective when installed on the building in which the energy is to be used, as this approach eliminates land-use competition issues, avoids the construction of stand-alone support structures and reduces problems of energy delivery (e.g. delivery costs and transmission losses). Furthermore, solar energy is unique and readily available as an on-site source of energy. As such, one of its greatest impacts will be at the home level, as various solar technologies can be combined to significantly reduce the need for outside energy. While an average house in Ontario used 116 GJ of outside energy annually in 2001 – this figure could be reduced to less than 50 GJ when solar energy usage is maximized and integrated with energy efficiency measures.

### PASSIVE SOLAR

Passive solar is mainly a design concept rather than a specific product. The contribution of passive solar design to space heating needs is a matter of arranging and using the various components of a building to gain and utilize net solar heat and light to achieve optimal effect. The energy balance of solar gains and losses through the building components provides the "net" energy. Properly designed homes can increase the sun's energy contribution for space heating and lighting loads, as well as reducing energy losses and cooling needs.

## 1.4 BENEFITS OF SOLAR ENERGY

The use of solar energy for electricity generation and for thermal applications provides unique opportunities to minimize dependency on imported fossil fuels and nuclear energy.

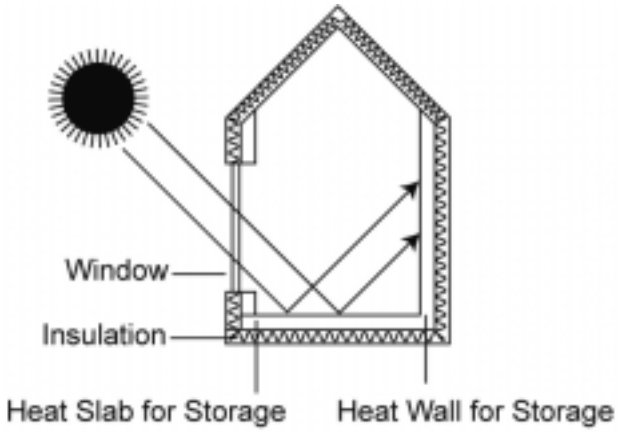



FIGURE 7 Passive solar design

Solar technologies such as PV are highly modular (i.e. can be easily adapted to meet changing energy needs) and can be used in grid-connected and stand-alone applications. PV systems can also be combined with other renewable energy systems (e.g. wind turbines, small hydro) to implement hybrid electricity systems that are increasingly used in difficult-to-access areas to displace cumbersome diesel generation.[18]

Solar technologies provide clean and reliable energy services without fuel costs. They can be used in all types of buildings and for commercial purposes (e.g. car washes, laundry facilities, and recreation facilities such as swimming pools and water parks).

Solar thermal technologies can help reduce the total energy bill of Ontarians and reduce their greenhouse gas emissions. For example, water heating represents about 20% of the average Canadian home total energy bill and results in an average of two tonnes of $CO_2$ emissions per water heater.[19] Solar water heaters can reduce the electricity or fossil fuels usually used for water heating by 40–50%. New solar systems can provide water heating at the equivalent of about five cents per kWh (competitive with electricity and natural gas prices).[20]

The development and implementation of solar technologies can also result in employment gains and new export products (as shown by the activities of key innovative Ontario-based solar companies).

## 1.5 EMPLOYMENT

Information on the job potential of the various solar technologies in Ontario is sketchy, at best, and there has been little empirical analysis of the current or potential size of the solar industry.

Employment creation analysis is further complicated by the diverse nature of the solar industries.

Passive solar is the largest single segment of the solar technologies in regard to actual energy generation; however, it is rarely acknowledged as an energy source and the jobs in this field tend to be included under general construction trades and window manufacturers. Therefore, the employment potential of solar passive options is not discussed in detail in this chapter.

Currently, the majority of solar manufacturing jobs in Canada are for products exported outside of Canada. Canada's four main solar manufacturers Conserval (solar air ventilation), Xantrex (inverters for PV), Thermo Dynamics (solar hot water collectors, and most recently

– Spheral Solar (PV modules) are focused on export markets with about 50–75% of their products being exported.[21] These firms are leaders in the solar industry internationally; however, the main reason for their high export ratios is because of the lack of a Canadian market for their products.

Employment in the solar sector tends to fall into manufacturing, installation, operations and maintenance.[22]

There are a wide variety of other indirect jobs associated with solar including the manufacturing of balance of system components, which for the technologies considered in this chapter include:

- PV system (batteries, inverters, mounting hardware)
- Solar hot water (pumps, plumbing, controls, mounting hardware, heat exchangers, water tanks)
- Solar pool heating (plumbing)
- Solar air ventilation (fabrication of metal, including ductwork and ventilation equipment)
- General: glass manufacturing, metal framing, control electronics, software.

As the solar installed capacity in Canada is still small, the number of jobs in the solar operations and maintenance sector is currently insignificant. As solar systems are installed on buildings and there is no technical operator (such as required by a wind farm or a hydroelectric facility), there is a need for firms to provide periodic maintenance. As deployment of solar technologies increase and the installed base expands, this sector will begin to contribute a significant number of jobs.

Currently, there is a lack of employment statistics on the solar industry in Canada and, unlike other OECD nations, there is no ongoing annual survey that tracks employment trends.

Nevertheless, a number of employment estimates exist and indicate that the Canadian PV industry currently provides between 600–1,000 jobs, and that the solar thermal industry supports about 180 jobs.[23]

At the moment the solar industry in Canada is very underdeveloped and few economies of scale are in place. Most manufacturing plants are operating at well under their capacities (25–33% is a figure often quoted), and installers are not working continually in implementing solar systems.[24] Therefore, the estimates provided here of jobs per installation in the solar industry might be higher than the actual jobs achieved if a much greater level of deployment was to develop.

### EMPLOYMENT POTENTIAL OF PHOTOVOLTAIC (PV)

The PV sector is expected to contribute to the creation of over two million jobs worldwide in 2020, mainly in small and medium sized firms.[25] However, analysis of the pertinent literature reveals a lack of consensus in methodologies and on job creation per MW of PV installed (i.e. a range of 13–185 jobs per MW installed).[26]

Due to the wide range of available estimates this chapter uses a figure of 35 jobs per MW of PV installed annually.

### EMPLOYMENT POTENTIAL OF SOLAR WATER HEATING

CanSIA estimates that six jobs can be created per 1,000 $m^2$ of solar hot water collectors installed not including maintenance personnel.

Canadian data for solar pool heating is not readily available, however, CanSIA estimates that for each 1,000 systems installed annually, 12 installation jobs and 1.6 maintenance jobs are created (these figures do not include any employment creation related to manufacturing).

### EMPLOYMENT POTENTIAL OF SOLAR AIR VENTILATION

Canadian figures are not readily available on the job creation potential for the solar air ventilation industry. Nevertheless, extrapolation of the present size of the industry versus new annual installations can provide a rough estimate of the magnitude of potential job creation.

According to Industry Canada, in 2003 there were 60 jobs and about 4,000 $m^2$ of solar air ventilation systems installed (manufacturer estimate). This would roughly translate to about 15 jobs per 1,000 $m^2$ of installed solar air ventilation systems (which is a very high employment estimation when compared to other solar technologies). Therefore, a preliminary estimate of five jobs per 1,000 $m^2$ is used, and it is emphasized that further research is required to derive a more accurate estimate.

### ONTARIO'S SOLAR JOB MARKET

Life expectancies of most solar technologies exceed 25 years, which is greater than the time frame considered in this study. However, as the market ages, there will be a growing need for system replacement, which will increase the job market. Solar pool heating – which has a typical life expectancy of 15–20 years will begin to see a significant replacement market develop during the next 20 years. However, this is not considered in the estimates used here.

Table 2 provides a tentative estimate of the job potential in the manufacturing and installation segments based on projected annual sales provided by the Canadian Solar Industries Association. No figures are provided for jobs created in maintenance and operation (except for solar pool heating).

### 1.6 ECONOMIC DEVELOPMENT

As of 2003, the annual Canadian PV module market totaled 1.67 MW per year and the Canadian PV industry generated revenues of about $100 million.[27] The industry is currently focused on off-grid applications and exports due to the absence of strong grid-connected markets. Even in the near absence of domestic markets, Ontario is currently home to leading solar companies, which are ready to increase their activities if supportive provincial policies are enacted to ensure rapid and sustained implementation of solar technologies.

## 2. Ontario's solar resource: waiting to be tapped

### 2.1 ESTIMATING ONTARIO'S SOLAR RESOURCES

As is the case with almost all of the renewable energy resources discussed in this report, Ontario's solar resources have not yet been thoroughly analyzed and information regarding the provincial solar resource is patchy at best, and not readily available. The resource estimations provided below are a preliminary attempt that indicates the magnitude of what can be achieved with solar energy in Ontario. Since local topographical features (including trees and existing buildings) can significantly affect the amount of solar radiation received in a specific area, this effort needs to be complemented by a detailed provincial analysis of solar resources at the community level.

The solar resource in Canada is generally very good and compares favourably with other regions of the world.[28] Within Canada, southern Ontario has one of the best national annual mean solar radiation regimes and, as Figure 1 illustrates, cities such as Toronto receive a very favourable solar resource (especially during summer, when key peaks of electricity demand occur).[29]

The next sub-sections look at the possible contribution that solar energy could provide in Ontario, using assumptions of roof availability for each solar application. These assumptions are then applied to projections of housing and building stock in 2025.

### 2.2 TECHNICAL RESOURCES

Solar systems (PV and thermal) are generally most effective when installed on buildings that can use solar energy (either as electricity and/or heat) on site. This strategy minimizes land-use conflicts and the need for construction of stand-alone support structures, while reducing energy delivery problems (e.g. need for grid expansions and associated energy transmission losses).

To estimate the total building area available for installing solar systems it is essential to determine the appropriate surfaces and roof types that are available in Ontario to implement solar systems.[30]

By analyzing the Ontario resale home market it is possible to develop an estimate of the proportion of surfaces and roof types in Ontario. This data is used in Table 3 to define an "average" solar system for residential applications.

**TABLE 2**

Potential solar job creation in Ontario by 2025

| | Jobs | | Market Size in 2025 | | | |
|---|---|---|---|---|---|---|
| **Technology** | | **Per unit** | | **Units** | | **Jobs in 2025** |
| PV | 35 | 1 MW | Annual sales | 135 | MW | 4,725 |
| | | | Total installed | 1,232 | MW | Not available |
| Solar air ventilation | 5 | 1,000 $m^2$ | Annual sales | 825,000 | $m^2$ | 4,125 |
| | | | Total installed | 3,600,000 | $m^2$ | Not available |
| Solar pool | 12 | 1,000 systems | Annual sales | 7,000 | Systems | 84 |
| | 1.6 | 1,000 systems | Total installed | 121,000 | Systems | 194 |
| Solar hot water | 6 | 1,000 $m^2$ | Annual sales | 1,719,000 | $m^2$ | 10,314 |
| **Total** | | | | | | **19,442** |

**TABLE 3**

Solar technology area requirements for residential applications

| Technology | System size | Solar system surface area ($m^2$) |
|---|---|---|
| Passive solar | To provide 33% of space heating load | 7 |
| PV | 3 kW array | 20 |
| Solar DHW | 2 collector system | 6 |
| Solar pool heating | 50% of pool surface area – average pool of 16'x32' | 26 |

The data of Table 3 is used to consider the available space on each roof type, considering its potential for shading, which is then compared to the size requirements for each solar application. Table 4 illustrates the results of this calculation and assumes that new construction (beginning in 2008) uses good solar orientation design and that favourable legislation protecting solar access is in place.

**TABLE 4**

Estimate of housing stock available for solar applications

| Technology | System sizing | Current (2001) | 2025 |
|---|---|---|---|
| Passive | With optimum solar exposure | 12% | 23% |
| PV | 3 kW Array | 47% | 51% |
| Solar DHW | For single family dwellings | 63% | 77% |
| Solar pool heating | For average swimming pool | 39% | 39% |

Considering provincial data on floor area and the number of building stories it is possible to derive estimates of Ontario's available roof space on commercial and institutional buildings.[31] This calculation indicates that by 2000 there were approximately 44 million $m^2$ of roof space on commercial and institutional buildings in Ontario.

By extrapolating historical building growth rates in Ontario it is possible to estimate that the building roof area in 2025 could increase to as high as 67 million $m^2$.[32]

## TECHNICAL POTENTIAL FOR PHOTOVOLTAIC SYSTEMS

**Residential PV:** Based on historical housing construction data, it is estimated that the number of houses in Ontario could grow to over 5,000,000 units by 2025.[33]

Currently, about 1,400,000 homes in Ontario (47% of all homes) have the potential to install a 3 kWp solar PV array that combined could supply 17% of the residential plug load demand in Ontario.[34]

Based on no improvements to homes' orientation or solar exposure it is possible to estimate that by 2025 almost 2,400,000 homes would have the technical potential to install a 3 kWp PV array, and that the total technical potential would be 7,100 MW or 7,100 GWh.

With proper legislation solving solar access and house orientation issues, the number of feasible roofs for 3 kW PV arrays for new homes could rise from the current 46% to 62% by 2025, thereby increasing the total housing stock's potential to 51% of all homes. This could increase the technical potential for PV-generated electricity by 11% to 7,900 MW (7,900 GWh) in 2025.

**Commercial & institutional rooftop PV:** It is assumed that 50% of commercial/institutional buildings currently have the potential for supporting PV systems on their roofs. It is important to note here that there is an overlap of the space requirements between PV and solar hot water systems. As the deployment of these two technologies

**TABLE 5**

Residential grid connected PV current technically feasible potential (2001)

| | Single detached | Semi attached | Row | Total |
|---|---|---|---|---|
| Number of housing units | 2,456,925 | 263,875 | 307,665 | 3,028,465 |
| Feasible sites | 44% | 52% | 57% | 47% |
| Number of feasible sites | 1,081,047 | 137,215 | 175,369 | 1,393,631 |
| Solar array size (kW) | 3 | 3 | 3 | |
| Technically feasible (MW) | 3,243 | 412 | 526 | 4,181 |
| Annual energy (GWh) | 3,243 | 412 | 526 | 4,181 |
| **Percent of total demand** | | | | **17%** |

**TABLE 6**

Residential grid connected PV technical potential in 2025

| | Single detached | Semi attached | Row | Total |
|---|---|---|---|---|
| Housing units – to 2008 | 2,730,349 | 312,466 | 382,809 | 3,425,624 |
| Feasible sites | 44% | 52% | 57% | 46% |
| Subtotal – feasible housing units | 1,201,354 | 162,482 | 218,201 | 1,582,037 |
| Housing units– built – 2008–2025 | 1,133,586 | 250,533 | 283,752 | 1,667,871 |
| Feasible sites | 59% | 65% | 75% | 62% |
| Subtotal – feasible housing units | 668,816 | 162,846 | 212,814 | 1,044,476 |
| Total Number of Feasible Housing Units | 1,870,169 | 325,329 | 431,015 | 2,626,513 |
| Solar Array Size (kW) | 3 | 3 | 3 | |
| Technically Feasible (MW) | 5,611 | 976 | 1,293 | 7,880 |
| **Annual Energy (GWh)** | **5,611** | **976** | **1,293** | **7,880** |

increases significantly there will be competition for roof space between the technologies.

Furthermore, it is also assumed that only 60% of the eligible roof space for solar systems is available for installations of PV as space is already taken up by HVAC equipment, roof access for window cleaners, and the spacing required between solar arrays to prevent array shading. As part of the technical resource calculations it is also assumed that PV modules will improve their performance efficiency slightly during the period considered (i.e. increase from 129 to 142 watts per $m^2$). Taking these numbers into consideration, it is estimated that the technically feasible potential of commercial rooftops in 2025 is 4,046 MW (or 4,046 GWh annually).

**Commercial and institutional facade BIPV:** Data on the fraction of wall area with adequate solar insolation for a wall mounted PV is derived from a European Commission report and data from German cities.[35] Applying this data, it is estimated that an average of 8% of building wall space has the potential for solar PV. A lower capacity fraction (0.61 kWh/watt vs. 1.0 kWh/watt) is used due to the reduced insolation on a vertical wall versus a sloped roof.

**TABLE 7**

Commercial rooftop PV – technically feasible potential (2000 & 2025)

| Year | 2000 | 2025 |
|---|---|---|
| Total number of buildings | 52,182 | 78,368 |
| Feasible sites | 50% | 50% |
| Number of feasible buildings | 26,091 | 39,184 |
| Roof area ($m^2$) | 44,878,716 | 67,399,524 |
| Average roof area ($m^2$) | 860 | 860 |
| Available roof area | 60% | 60% |
| PV array tilt aspect (45° vs. flat) | 141% | 141% |
| Average array area available ($m^2$) | 728 | 728 |
| PV efficiency (watt/$m^2$) | 129 | 142 |
| Average array size (kW) | 94 | 103 |
| Total power (MW) | 2,449 | 4,046 |
| Annual energy produced (GWh) | 2,449 | 4,046 |

**TABLE 8**

Commercial/institutional building facade BIPV (2025)

| | 2000 | 2008 | 2025 |
|---|---|---|---|
| No. of buildings | 52,182 | 59,434 | 78,368 |
| Wall area ($m^2$) | 1,797,476,509 | 2,047,295,229 | 2,699,477,007 |
| Increase in wall area | | | 652,181,779 |
| Fraction of facade available for BIPV | | | 25% |
| Fraction of façade with adequate solar irradiation | | | 8% |
| Façade available for PV ($m^2$) | | | 13,043,636 |
| PV efficiency (watt/$m^2$) | | | 142 |
| Total power (MW) | | | 1,852 |
| Annual energy output (kWh/watt) | | | 0.61 |
| Annual energy produced (GWh) | | | 1,121 |

Table 9 illustrates that the total technically feasible potential for PV in Ontario by 2025 is equivalent to 13,778 MW.

**TABLE 9**

Ontario's grid connected PV technically feasible potential (2025)

| Building type | Capacity (MW) | Energy (GWh) |
|---|---|---|
| Residential rooftops | 7,880 | 7,880 |
| Commercial rooftops | 4,046 | 4,046 |
| Commercial façade BIPV (new buildings) | 1,852 | 1,120 |
| **TOTAL** | **13,778** | **13,046** |

### TECHNICAL POTENTIAL FOR SOLAR AIR VENTILATION

The current markets for solar air ventilation are primarily in the commercial/institutional and industrial markets where large volumes of fresh air are required. These two markets are analyzed separately due to the different methods used to report energy use.

**Solar Air Ventilation (SAV) for commercial/institutional buildings:** This chapter considers the potential only for new construction occurring between 2008–2025. By displacing costs associated to new construction with SAV, the economics improve dramatically and it is assumed that this market will develop faster than the retrofit market. Limiting the study to new construction will underestimate the technically feasible potential considerably. However, the numbers will more closely reflect the market potential. Projections on the amount of new wall area through to 2025 were based on historical data of buildings, average number of floors, and floor area in commercial/institutional buildings.[36]

It is assumed that about 8% of walls on all new buildings have the potential of using SAV; however it is estimated that only 10% of those walls are available for solar air ventilation systems (the remainder being used for windows, doors, or shaded). This would indicate that the technically feasible potential would be about 0.8% of all wall space. Assuming that the necessary mechanisms to reduce the barriers to this technology are introduced by 2008 then this would equate to 650,000,000 $m^2$ of potential wall space and an annual energy output of 10 PJ by 2025 in commercial buildings.

**Solar air ventilation for industrial buildings:** Estimating the technically feasible potential for industrial buildings is difficult because building size data is not readily available. Furthermore, available energy usage data is not separated between different building loads (such as process energy and operational building energy needs). Therefore, it is estimated here that if changes in building orientation are introduced after 2008 then the sites where solar can be used could increase from 25% to 50%.[38] It is estimated that SAV has the technical potential to supply 3.95 PJ in the industrial segment by 2025.

**TABLE 10**

Technical potential of commercial solar air ventilation in Ontario by 2025

| | 2000 | 2008 | 2025 |
|---|---|---|---|
| No. of buildings | 52,182 | 59,434 | 78,368 |
| Wall area ($m^2$) | 1,797,476,509 | 2,047,295,229 | 2,699,477,007 |
| Increase in wall area | | | 652,181,779 |
| Fraction of façade with adequate solar irradiation | | | 8% |
| Fraction of façade available for solar air ventilation | | | 10% |
| Façade available for solar ($m^2$) | | | 5,217,454 |
| Energy output @ 2 GJ/$m^2$ (PJ)[37] | | | 10 |

**TABLE 11**

Current industrial SAV technical potential in Ontario

| | Feasible | Fuel (PJ) | Solar (PJ) |
|---|---|---|---|
| Electrical | 3.75% | 6.34 | 0.24 |
| Gas | 3.75% | 18.05 | 0.68 |
| **Total** | | **24.39** | **0.91** |

**Total technically feasible potential for Solar Air Ventilation (SAV):** It is estimated that the technically feasible potential for SAV in Ontario for new buildings (built after 2008) can be 14 PJ. However, the market considered in this study represents only about 24% of all non-residential buildings, and thus the total technical potential could be in the range of 56 PJ (15,500 equivalent GWh). However, we have used the lower number (14 PJ) in this chapter.

### TECHNICAL POTENTIAL FOR SOLAR HOT WATER (SHW)

Technical estimates are broken down according to residential, commercial, and swimming pool sectors.

**Residential solar water heating:** It is estimated that 2,228,000 residences in Ontario could use solar energy for heating water. This total could rise to 4,737,000 housing units by 2025 with proper house planning and adequate solar access legislation in place.[39]

**TABLE 12**

SDHW technical feasible percentage of homes

| | | Single detached | Attached | Apartments (low-rise) | Total |
|---|---|---|---|---|---|
| 2001 | Number of housing units | 2,456,925 | 571,540 | 1,166,475 | 4,194,940 |
| | Feasible sites | 63% | 65% | 27% | 53% |
| | Potential no. of solar units | 1,547,863 | 371,501 | 309,116 | 2,228,480 |
| 2025 no planning | Number of housing units | 3,863,935 | 1,229,560 | 1,772,427 | 6,865,922 |
| | Feasible sites | 63% | 65% | 27% | 54% |
| | Potential no. of solar units | 2,434,279 | 799,214 | 478,555 | 3,712,048 |
| 2025 w legislation | Number of housing units | 3,863,935 | 1,229,560 | 1,772,427 | 6,865,922 |
| | Feasible sites | 77% | 90% | 37% | 69% |
| | Potential no. of solar units | 2,975,230 | 1,106,604 | 655,798 | 4,737,632 |

Table 13 summarizes Ontario's total residential hot water use by dwelling type.

**TABLE 13**

Ontario's residential hot water usage (2001)[40]

| | Single detached | Attached | Apartments | Mobile homes | Total |
|---|---|---|---|---|---|
| 2001 (PJ) | 61.7 | 16.5 | 30.3 | 0.8 | 109.2 |

Currently 63% of Ontario's single detached homes have the technical potential to install a solar water heater. The average total amount of hot water that can be supplied using solar currently is about 42% in Ontario.[41]

The technically feasible potential of SDHW in 2025 relates, to a large amount, to how buildings will be built. If new homes are installed using current practices (i.e. no consideration to building orientation as it relates to southern exposure or seasonal cycles) then technically feasible potential in 2025 will be 37.1 PJ.

If housing units are oriented correctly to take advantage of available solar resources and solar access legislation is enacted to ensure maximum use and unimpaired access to solar resources, then the potential rises from 63% of single detached homes to 77% and the technically feasible potential rises to 56.4 PJ by 2025.

**TABLE 14**

Solar domestic hot water (SDHW) technically feasible potential (2001)

| | Single detached | Attached | Apartments | Mobile homes | Total |
|---|---|---|---|---|---|
| Feasible sites | 63% | 65% | 27% | 0% | |
| Solar fraction | 42% | 42% | 42% | 42% | |
| Technically feasible | 26% | 27% | 11% | 0% | |
| Annual solar energy (PJ) | 16.3 | 4.5 | 3.4 | 0.0 | 24.2 |

**TABLE 15**

SDHW technically feasible potential (2025) – with planning

| | Single detached | Attached | Apartments | Mobile homes | Total |
|---|---|---|---|---|---|
| Feasible sites | 77% | 90% | 37% | 0% | |
| Solar fraction | 50% | 50% | 50% | 50% | |
| Technically feasible | 39% | 45% | 19% | 0% | |
| Annual solar energy (PJ) | 35.1 | 15.6 | 5.7 | 0.0 | 56.4 |

**Commercial Solar Hot Water (SHW):** In 2001 the commercial sector used about 24.8 PJ for its hot water needs. Natural gas was used to provide close to 95% of the energy needed to heat water in this sector (oil and electricity provided the remainder). The estimated number of commercial sites where it is technically feasible to use solar water heating and the potential of solar is listed in the Table below.[42] As most commercial buildings have flat roofs and are multi-storey (implying low shading issues), then the fraction of technically feasible sites is not expected to increase significantly through to 2025. Solar water heating has the technical potential to provide 8.8 PJ of the hot water needs of the commercial building segment by 2025.

It should be noted that there is a very high potential for commercial solar water heating in specific market segments, most specifically hot water intensive industries such as food processing, because installed costs are lower and energy consumption can be very high. More research is required into this market segment to highlight opportunities.

### SOLAR HEATING OF SWIMMING POOLS

It is estimated that the pool market in Ontario will grow from 207,000 (1998) to 415,500 by 2025 and that 59% of pools will continue to be heated (10% from solar). Based on the present market and business-as-usual scenario,

**TABLE 16**

Commercial solar water heating potential

| Building type | 2001 PJ | Technically feasible sites | Typical solar fraction | Technically feasible | Annual solar energy (2001) PJ | Annual solar energy (2025) PJ |
|---|---|---|---|---|---|---|
| Schools | 2.5 | 60% | 42% | 25.2% | 0.63 | 0.92 |
| Health care institutions | 4.9 | 60% | 42% | 25.2% | 1.23 | 3.92 |
| Religious institutions | 0.8 | 60% | 42% | 25.2% | 0.20 | 0.24 |
| Other institutions | 2.0 | 40% | 42% | 16.8% | 0.34 | 0.86 |
| Offices | 5.1 | 0% | 42% | 0.0% | – | – |
| Retail organizations | 2.7 | 5% | 42% | 2.1% | 0.06 | 0.10 |
| Hotels and restaurants | 4.5 | 40% | 42% | 16.8% | 0.76 | 2.17 |
| Recreational facilities | 1.8 | 40% | 42% | 16.8% | 0.30 | 0.48 |
| Warehouses | 0.6 | 40% | 42% | 16.8% | 0.10 | 0.12 |
| **Total** | **24.8** | | | | **3.62** | **8.8** |

pools that are heated using solar energy could grow from the current 22,500 (2001) to 41,500 pools in 2025.

Currently it is estimated that there are over 22,000 pools in Ontario that are solar heated and it is estimated that a further 43,000 pools could potentially use solar heating with a savings of 2.6 PJ of conventional energy sources.

Based on these figures it is estimated that 39% of pools have the potential of using solar energy, which indicates a technically feasible market of 120,000 pool installations by 2025.

### PASSIVE SOLAR DESIGN (PSD)

The technically feasible residential potential of PSD in Ontario is 145 PJ annually by the year 2025, based on estimates for new house construction in Ontario and on the feasibility of using solar energy in buildings.

Passive solar energy can play a significant factor in reducing the energy demand in large buildings. However, it is beyond the scope of this chapter to cover this wide topic. There is a lack of current Canadian studies available in this area and a proper study should be conducted to identify the potential and possible mechanisms on how solar can contribute more to this building sector. The few existing Canadian reports on this topic indicate that solar daylighting provides over 25% of the lighting energy required in large buildings (daylighting refers to the use of natural light to illuminate buildings rather than relying on artificial lights powered by electricity).[44] The contribution can be increased to 30–70% where daylighting designs are used, and this is an important solar option as lighting loads can account for 10–20% of electricity use in large buildings.[45]

## 2.3 PRACTICAL RESOURCE

Although Ontario's technical solar potential is very large, its development is constrained by a number of physical factors, and by what is considered a financially viable market share.

No recent studies have been done in Canada on levels of market share as they relate to payback for renewable

**TABLE 17**

Current (2001) potential for solar pool heating in Ontario[43]

| | Resistance heater | Natural gas/propane | Heating oil | Heat pump | Electricity (res & heat pumps) | Total |
|---|---|---|---|---|---|---|
| Energy supplied by source | 3% | 39% | 0% | 6% | 9% | |
| No. of pools | 7,196 | 87,700 | – | 14,167 | 21,363 | 109,063 |
| Energy supplied by source (PJ) | 0.3 | 3.9 | – | 0.6 | 0.9 | 4.8 |
| Heater efficiency | 100.0% | 67.5% | | 100.0% | 100% | |
| Energy consumed (PJ/year) | 0.3 | 5.7 | | 0.6 | 0.9 | |
| Feasible sites for solar | 39% | 39% | | 39% | 39% | |
| No. of pools with solar potential | 2,806 | 34,203 | | 5,525 | 8,332 | 42,535 |
| Energy savings (PJ/year) | 0.1 | 2.2 | | 0.2 | 0.4 | 2.6 |
| **Energy savings (GWh/year)** | **34** | **620** | | **68** | **102** | |

energy systems. However, it is reasonable to assume that a significant shift in public attitudes may have occurred since the late 1980s when the last report on this issue was done.[46] Therefore, it is recommended that the province initiate a study of this issue as soon as possible.

For the remaining resource estimations of this chapter the payback acceptance curve that was developed in 1989 by Synergic Resources Corporation was used due to the lack of a more current model. The figure below shows the percentage of buyers that would purchase an energy-saving device for the residential, industrial, commercial and institutional markets. It is important to emphasize that currently there is essentially no market demand for products with greater than a seven to eight-year payback (except by innovators).[47]

While institutions and governments often claim to accept longer paybacks than industry, tight budgets and capital spending limitations cause only the most cost-effective measures to be implemented unless the purchases are legislated.

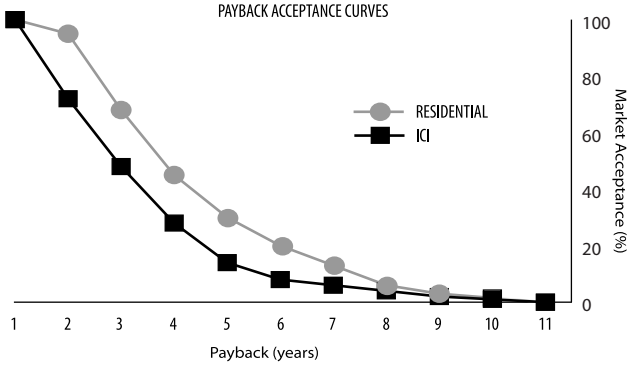



FIGURE 8 Technology acceptance based on payback

Deployment estimates for solar technologies are based on these curves (with reference to the technical potential of each solar segment).

In addition, it needs to be considered that a small industry may be able to sustain double or even triple digit growth for short periods of time (five years or less) when the market penetration is extremely small. Moving from sales of 100 units to 300 units is easier to accomplish than a sales increase from 100,000 to 300,000 though the growth rate is still the same. For the analysis of resource potential, it is estimated that the short-term sustainable growth of the solar industry is 50% annually.

This estimate assumes that the crucial issues outlined below will be addressed by policy-makers to thereby achieve the solar development potential summarized here.

**Manufacturing capacity:** Manufacturing plant capacity can be a limiting factor when large sales growth is experienced, as it may take a year or more to build new capacity. Therefore, industrial planning and innovation needs to be actively fostered and supported by all levels of government.

**Expansion of the workforce:** Training of the workforce can have a major limiting effect to growth. Solar technologies require labour with special training to ensure that systems are properly designed and installed, and that they operate at optimum performance. Current initiatives such as the Renewable Energy Program of the Association of Canadian Community Colleges provide a valuable example of the type of programs that need to be augmented and designed for the secondary and post-secondary systems.[48]

**Access to working capital:** The solar industry in Canada currently consists of small firms. Small businesses historically have a difficult time accessing capital. Solar businesses represent unknown territory for most investors, and therefore have an extremely difficult time raising capital at favourable terms. This problem represents a major limit to how fast the solar industry can grow and to be addressed (for example, through education initiatives and active industry-government collaborations).

**Access to finance and performance incentives:** Although some solar technologies are already cost-competitive in Ontario when initial costs are accounted over the life of the system (e.g. solar water heaters, solar ventilation), others are still not (e.g. grid-connected PV). Access to finance at attractive interest rates (for example through interest-free or low-interest revolving loans) is essential to enable sustained and large-scale adoption of solar systems, and needs to be coupled with renewable energy mechanisms that allow system owners to receive an adequate payment for each kWh of excess power that their systems produce.

## 2.4 ACCEPTABLE RESOURCE

### PHOTOVOLTAIC (PV)

It is impossible to accurately predict what constitutes an acceptable market potential of PV in Ontario by 2025 without a prediction of electricity prices and PV cost reductions, which are beyond the scope of this chapter. PV is currently not in the same situation as the other

solar technologies discussed here, which have payback periods ranging from 1–10 years, and that have as a main barrier the financing of systems over a medium (10-year) time frame.

Nevertheless, it can be safely assumed that PV's growth potential is increasing each year as electricity prices grow and its installation costs are reduced.

The charts below illustrate two potential scenarios. Scenario 1 assumes that PV prices continue to drop by 5% annually (historical average), electricity prices in Ontario increase by 4% annually with a starting price of $0.08 per kWh, and that solar is amortized over 20 years. In this scenario PV achieves the cost of utility supplied electricity by 2024.

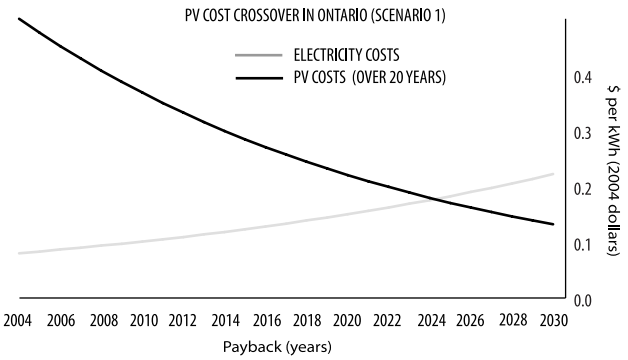



FIGURE 9 PV cost crossover in Ontario (Scenario 1)

The second scenario uses the cost of electricity at peak times (assumes 50% above the average). Solar PV produces electricity during peak times, and the benefits and savings will be greater if this is taken into consideration. In this scenario the cost of solar is amortized over 30 years (most PV modules have a 25-year warranty with a minimum life expectancy exceeding 40 years). In this scenario the crossover point of solar PV occurs 9 years earlier, in 2015.

If prices were to drop quickly to $5.50 per watt installed (currently they are in the range of $10/watt installed) as has been suggested, or as the peak cost of

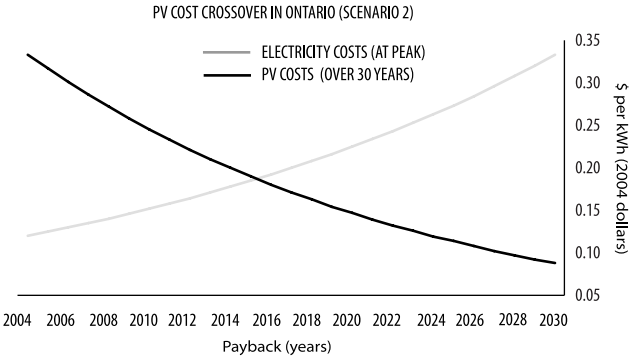



FIGURE 10 PV cost crossover in Ontario (Scenario 2)

electricity increases faster (middle of day prices are 50–100% higher than the rates currently billed) then the cost crossover point could occur considerably sooner.[49]

The estimate on potential solar markets in 2025 are based on the following:

- An early adopters program funded by REM;
- A provincial Net Zero Energy Homes initiative for new homes;
- A BIPV program on government buildings and schools.

With an "Accelerated PV Price Drop" scenario with a cost crossover occurring in around 2015, it is estimated that 1,263 MW of PV, generating 1,263 GWh, could be installed on the electrical grid by 2025 with government support for REMs.

This estimate is comparable to the one suggested by a recent Pembina Institute/Canadian Environmental Law Association report (1,000 MW by 2020).[50]

As the cost crossover point is approached, the issue of deployment growth becomes one of financing the installation costs (similar to the current situation faced by solar domestic hot water systems), rather than that of the economics of electricity generation from PV.

In addition there are significant industry barriers, including limits to an industry's sustainable growth that must also be addressed before higher PV installation

**TABLE 18**

PV in Ontario – the market potential (2025)

| | | | | |
|---|---|---|---|---|
| Early adopters program | 1,000 homes a year for 10 years | 10,000 homes | 30 MW | 30 GWh |
| NZEH initiative | 2% incremental growth rate of new home construction | 420,000 homes | 1,232 MW | 1,232 GWh |
| BIPV demonstration | 100 kW per year for 10 years | | 1 MW | 0.6 GWh |
| **Total installed** | | | **1,263 MW** | **1,263 GWh** |

numbers are achievable. The province needs to prepare itself for the wide introduction of PV on the grid and therefore it is critical that the provincial government initiates a number of programs to increase the solar industry's capacity to handle rapid growth, and to educate policy and decision makers on the multiple environmental and social benefits of PV and its significant expansion potential.

### SOLAR AIR VENTILATION (SAV)

Assuming the current annual growth rate of 6.5% for SAV would mean that the industry would supply 0.31 PJ of energy by 2025.

Under an accelerated scenario, considering the market potential for solar air ventilation systems by 2025, it is assumed that a key caveat is the amount of growth that the SAV industry can maintain over an extended time frame. Therefore, it is estimated as an annual growth of 50%, starting in 2008 for five years, and then an annual growth of 30% thereafter.

**TABLE 19**

The market potential of SAV in Ontario

| | Business as usual | Accelerated | Increase |
|---|---|---|---|
| Annual growth rate | 6.50% | 30–50% | |
| Annual installed in 2025 ($m^2$) | 9,000 | 825,000 | 816,000 |
| Total installed by 2025 ($m^2$) | 156,000 | 3,586,000 | 3,430,000 |
| Annual sales (2025) | $19.5M | $363M | $343M |
| Cost reductions (annual) | 0% | 1% | |

In the accelerated scenario it is projected that an additional 816,000 $m^2$ of solar air ventilation systems could be installed annually by 2025 in commercial and industrial buildings in Ontario – this represents the manufacturing capacity that already currently exists in Ontario. Although current manufacturing capacity is focused to satisfy foreign demand, it is estimated that the industry could manage the expected growth in production. The availability of a trained workforce is not considered to be a barrier as workers can be drawn from the existing construction industry. By increasing the sales to the accelerated scenario it is estimated that the SAV industry could reduce costs by an average of 1% annually due to economies of scale.

By 2025 the commercial and industrial solar air ventilation potential in the accelerated growth scenario would contribute over 7.17 PJ (or the equivalent of 1,991 GWh per year). This solar contribution represents about 50% of the technical potential in this market segment.

### SOLAR HOT WATER (SHW)

Two scenarios are considered in this section. The first is based on a business-as-usual scenario that assumes an annual growth rate of 10% for the current SHW market. The accelerated scenario assumes that a financing program is in place with a pilot program initiated in 2005 (700 systems in two years), which is then followed by annual sales growth of 50% a year (achieving 5,000 system installations annually by 2011) for five years and then growing at current typical international growth rates of 30% over the remaining period (2012–2025).

It is assumed that growth limitations are not relevant in the SHW industry because there is current capacity in Canada to manufacture over 40,000 residential systems annually and the Canadian domestic market is very small compared to international markets.[51]

Based on the accelerated adoption scenario, it is estimated that over 800,000 solar residential hot water systems could be installed in Ontario by 2025 and a further 2,000,000 $m^2$ of solar collectors could be installed for commercial systems.

**TABLE 20**

SHW market potential (2025)

| | | Business as usual | Accelerated |
|---|---|---|---|
| Total Installed | $m^2$ | 53,000 | 6,800,000 |
| | Energy (PJ) | 0.103 | 13.57 |
| | Energy (eGWh) | 29 | 3,772 |
| Residential | $m^2$ | 35,000 | 4,800,000 |
| | Systems | 5,800 | 800,000 |
| | Energy (PJ) | 0.070 | 9.600 |
| Commercial | $m^2$ | 1,655 | 2,000,000 |
| | Energy (PJ) | 0.033 | 3.969 |
| System Cost in 2025 | | $3,500 | $2,290 |
| **Total Sales (2005–2025)** | | **$31M** | **$2,990M** |

### SOLAR HEATING OF SWIMMING POOLS

While this is a mature market that does not require government support to continue growing at the same rate as new pool installations – it remains stuck with about a 10% market share for pool heaters. The main impediment to increasing sales in this market is the lack of customer familiarity with the product (i.e. insufficient marketing), a reluctance of pool installers to sell solar systems due to the perceived complexity of the installation (i.e. lack of information) and the higher initial investment that is required for solar systems versus heaters that use non-renewable energy sources (payback acceptance curve).

Removing marketing and education barriers could improve the market share to 45% based on a three-year payback acceptance curve for solar pool heaters.

If a financing mechanism was introduced to reduce payback time to one year, the market share could increase to close to 100% of its technically feasible market. This would improve the market for solar pool heating from the business-as-usual scenario of 41,000 systems installed, to 120,000 systems by 2025 – representing 29% of all pools and 49% of all heaters. A large market share in the heater market is viable as solar heaters do not in all cases replace an existing heater (e.g. the original heater can be still be used to back up the solar system).

**TABLE 21**

The market potential for solar pool heating by 2025

| By 2025 | Business as usual | Accelerated growth |
|---|---|---|
| Installed | 41,000 systems | 120,000 systems |
| Increase | 16,500 systems | 95,500 systems |
| Sales (2005–2025) | $65M | $390M |
| Energy produced in 2025 | 1.9 PJ | 6.6 PJ |

No major industry growth barriers exist, as the Ontario market size is still small and the labour force could be drawn from the pool industry and summer students. An accreditation program for the companies who would install under the proposed incentive program summarized in Table 24 would ensure that installations are done properly.

### PASSIVE SOLAR DESIGN (PSD)

By improving the building stock of new homes in Ontario starting in 2008, it would be possible to achieve a market potential for residential PSD in Ontario by the year 2025 of 86 PJ (or the equivalent of 23,800 GWh) annually. To visualize the potential of this contribution, consider that in 2001 Ontario's total load of space heating required about 299 PJ of energy, which was provided predominantly by natural gas.[52]

## 2.5 ONTARIO'S ACHIEVABLE SOLAR CONTRIBUTION

### ONTARIO'S SOLAR POTENTIAL IN 2010

As the solar market and the solar industry in Canada is so small, significant growth must occur before solar technologies begin to make a significant impact. If the initiatives recommended in this chapter are implemented by 2008 then the impact of solar technologies by 2010 will still be at an incipient stage. However, the compound double-digit growth that solar technologies have consistently experienced will allow the solar sector to be a significant source of Ontario's energy by 2025.

**TABLE 22**

Solar energy use in Ontario (2010)

| Application | Solar total (PJ) | Total solar systems |
|---|---|---|
| Residential | | |
| Solar DHW | 0.11 | 9,500 systems |
| Swimming pools | 1.50 | 35,000 systems |
| PV on homes | 0.24 | 25,000 systems |
| Passive solar heating | 29.00 | 22,000 homes |
| Commercial & Institutional | | |
| Solar hot water | 0.04 | 20,000 $m^2$ |
| PV on roof tops | 0.001 | 300 kW |
| BIPV facades | 0.0007 | 300 kW |
| Industrial & Commercial | | |
| Solar air ventilation | 0.17 | 83,000 $m^2$ |
| Total | | |
| Total energy (PJ) | 31.06 | |
| **Total energy (GWh)** | **8,628** | |

### ONTARIO'S SOLAR POTENTIAL IN 2025

Solar energy has the technically feasible potential of supplying 21% of the energy in the market segments reported on this study by 2025. Half of this technical potential could be achieved if the initiatives discussed in this chapter are implemented. At this level of adoption, solar energy would provide as much energy in 2025 as coal did in 1999, or about half the electricity generated by all of Ontario's nuclear power plants.

**TABLE 23**

The market potential for solar by 2025

| Application | Solar total (PJ) | Total solar systems |
|---|---|---|
| Residential | | |
| Solar DHW | 9.60 | 800,000 systems |
| Swimming pools | 6.60 | 120,000 systems |
| PV on homes | 4.54 | 430,000 systems |
| Passive solar heating | 85.67 | 420,000 homes |
| Commercial & Institutional | | |
| Solar hot water | 3.97 | 2,000,000 $m^2$ |
| PV on roof tops | 0.004 | 1000 kW |
| BIPV facades | 0.002 | 1000 kW |
| Industrial & Commercial | | |
| Solar air ventilation | 7.17 | 825,000 $m^2$ |
| **Total** | | |
| **Total energy (PJ)** | **117.56** | |
| **Total energy (GWh)** | **32,656** | |

### 2.6 GROWTH QUICKENS IN NEW MARKETS

Surveys of the world's PV market consistently show that growth rates of 30% or more have become an established trend.[53] These high growth rates are leading to a general continuing downward trend in grid-connected PV system prices.[54] Analysis of the long-term outlook for the leading PV markets of Japan, Germany, and California shows that these markets will continue to grow.[55]

The quick rise and sustained buoyancy of the German and Japanese markets are a direct result of government implementation of supportive market transformation policies. Germany's PV leadership in Europe is a direct consequence of the implementation of its sophisticated renewable energy feed-in law, which mandates that utilities connect PV systems to the electric grid and that they purchase electricity at fixed minimum prices.

In addition to this key policy strategy, Germany and Japan have implemented initiatives to provide access to system finance ("solar roofs" programs), and comprehensive education programs that act synergistically to creative active solar PV markets.[56]

Markets for solar water and space heating are also increasing at impressive rates and provide examples of what can be achieved in Ontario. For example, between 2000 and 2001 these markets grew by 26% per year, while the market of solar swimming pool heating grew by 23%.[57] All solar thermal systems installed by the end of 2001 generated the equivalent of 41,795 GWh (150,463 TJ), which corresponds to an oil equivalent of 6.7 billion litres, and helped to avoid the annual emission of 18.2 million tonnes of $CO_2$.[58]

Solar thermal markets are currently dominated by China's domestic demand (which has an ambitious national target of 65 million $m^2$ of solar collectors by 2005 in its 10th Five Year Plan) and by Germany, which has achieved a ten-fold market expansion since 1991. Germany currently offers generous market incentives for thermal systems and is exploring the potential of adapting its feed-in laws to the solar thermal sector. Other market success stories include Israel, which 20 years ago introduced legislation requiring new buildings to place solar thermal systems on their roofs and can boast today that 80% of all its residential buildings are now equipped with solar water heaters.[59]

## 3. Policies, mechanisms, and incentives to enhance solar power implementation

### 3.1 SOLAR ELECTRICITY (PV)

While all the solar thermal technologies discussed in this chapter are cost-effective and ready for wide deployment in Ontario, there are still significant barriers surrounding the use of PV in grid-connected applications. Government involvement is essential to facilitate dismantling key barriers such as inadequate price incentives, poor access to finance, and limited public awareness, which are actively preventing the widespread use of PV in the province.

More specifically, residential and commercial customer participation in the implementation of grid-connected PV in Ontario are hampered by:[60]

- Cumbersome access to the grid for owners of PV systems;
- Lack of guaranteed premiums for PV-generated electricity;
- Very limited provincial awareness on the current options available for using PV and PV's numerous financial and non-financial benefits;
- Technological availability and high initial cost;
- Poor financing rates and terms.

Many of these issues can be addressed through strong program design. However, to maximize provincial participation it is necessary to have effective policy mechanisms that go beyond the net-metering approach currently used in North America. The fact is that without other financial incentives, net metering is not enough to increase market penetration as the experience of California and Texas clearly illustrates.[61]

The successful PV programs of the two world leaders on this technology, Japan and Germany, clearly illustrate the effectiveness of innovative policy mechanisms such as feed-in laws (referred here as renewable energy mechanisms or REMs), and the importance of a combination of other supportive initiatives to overcome barriers (government support of public education, R&D, training, access to finance).

REMs have two essential components: stable and carefully calculated payments for each kWh of PV-generated electricity (which are regularly reviewed to

ensure market development), and the right to connect to the electricity grid.

The design and implementation of REMs in Ontario needs to be supported by a provincial PV Deployment Program that addresses the following issues:

EDUCATION AND COMMUNICATION

- Renewable energy education programs to build demand for distributed renewables and increase the public interest in PV;
- Effective tracking and monitoring of program initiatives to identify and correct barriers to the wider use of PV.

TECHNICAL ISSUES

- Clear and simple interconnection standards that are uniform across Ontario and compatible with those in other provinces;[62]
- Support for equipment suppliers by facilitating testing and certification by a standards testing agency (such as CSA or Measurements Canada), and by listing in a directory of certified suppliers.

FINANCING ISSUES

- Development of favourable financing mechanisms for customers purchasing distributed renewable energy systems (e.g. a federal-provincial interest-free revolving loan system to facilitate purchase of PV systems);
- Simplified and standardized contracts for potential PV implementers.

An action plan for mainstreaming PV in Ontario should focus on a number of separate, yet interdependent initiatives:

- An early adopters program (for existing homes);
- A net-zero energy home initiative (for new homes);
- A Building Integrated PV (BIPV) demonstration program using government buildings to showcase the technology and stimulate learning by doing;
- Solar access legislation including zoning and building code strategies to protect solar access and to prepare new homes for PV retrofits (so new homes can be solar-ready even if systems are not implemented at the time of construction);
- A PV financing program (e.g. a federal provincially-sponsored revolving program to provide interest free loans);
- A public awareness education program.

## 3.2 SOLAR THERMAL

SOLAR AIR VENTILATION (SAV)

Currently there are three main barriers to the greater deployment of SAV systems in Ontario:

- Lack of knowledge about the product and its features and benefits (including a reluctance of the design community to specify solar heating);
- A payback period of four to six years (for new construction), which reduces the potential market to under 20% of potential buyers using the payback acceptance curve;
- Owners of commercial buildings are usually not the energy consumers and there is little incentive for owners to install energy saving equipment as the energy bills are passed directly on to the tenants.

If these barriers were eliminated, then the market for solar air ventilation would achieve the accelerated scenario by 2025.

Support initiatives for SAV would include solar access legislation, solar-ready standards and codes for new buildings, solar certification and listing in an ad-hoc directory, tax incentives, and solar procurement by government. More details are provided on these initiatives below.

SOLAR HOT WATER (SHW)

Currently there are three main barriers to the greater deployment of solar hot water systems in Ontario:

- Lack of knowledge of the product, its current features, and numerous benefits.
- Current payback periods of 7–15 years, which reduce the potential market to under 5% of potential buyers.
- For commercial systems the owners of commercial buildings are usually not the energy consumers and there is little incentive for them to install energy saving equipment as the energy bills are passed to the tenants.

If these three main barriers were eliminated then the market for solar hot water systems would achieve the accelerated scenario by 2025.

Support initiatives for SHW would include solar access legislation, solar-ready standards and codes for new buildings, solar certification and directory, tax incentives, expanded tax write-offs, promotion of SWH as part of a zero-energy home program, and solar procurement by government. More details are provided below.

### SOLAR POOL HEATING (SPH)

The primary barriers to wider deployment of solar pool heating relate to a lack of coordinated marketing and the need for system financing.

While this market's energy needs can be considered as a relatively small fraction of Ontario's total energy needs, the solar contribution of this market can be quite significant (with the equivalent of potential savings of 1,330 GWh annually by 2025).

A government program for solar installations in this segment can have high synergistic potential to increase residential and commercial hot water markets and can be rapidly deployed. It would also send a strong message to Ontario residents about the government's commitment to developing solar technologies.

Support for SPH would include solar access legislation, solar certification and listing in an ad-hoc directory, special promotion programs, and tax incentives. More details are provided below.

### PASSIVE SOLAR (PS)

Many of the initiatives for increasing the deployment of passive solar to reach maximum market potential by 2025 relate to policy and legislation. Passive solar is cost-effective now, as it is mainly a design issue with no significant materials costs. The main barriers to a wider use of the technology in Ontario include:

- Lack of information on its potential;
- Lack of demonstrations throughout Ontario;
- Builders have no incentive to build houses with a high solar fraction, as there is no market demand at the moment nor legislation to ensure the maximum possible use of PS design;
- Buildings do not have dedicated access to the solar resource (as right to light and building orientation issues are not protected by legislation).

Support initiatives for PS would include solar access legislation, solar certification and directory, promotion of PS as part of a zero-energy home program, tax credits for advanced windows, and solar procurement by government. More details are provided below.

### IMPLEMENTING SOLAR INITIATIVES IN ONTARIO

The remainder of this section summarizes 14 initiatives

**TABLE 24**

Summary of policy initiatives to increase solar energy use in Ontario

| | Technology | | | | | Program type | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Initiative** | **SHW** | **SPH** | **SAV** | **PV** | **PS** | **L** | **M** | **S** | **T** |
| i. Solar access legislation | X | X | X | X | X | X | | | |
| ii. AREM marketing | | | | X | | X | X | X | |
| iii. Solar ready | X | | | X | | | X | | |
| iv. Solar financing program | X | | X | X | | | | X | |
| v. Solar certification & performance directory | X | X | | | | | X | X | |
| vi. PV early adopters program | | | | X | | | | X | |
| vii. Expanding corporate income tax write-off | X | | X | | | | | | X |
| viii. Setting a minimum solar fraction in the building code | | | | | X | X | | | |
| ix. Improve commercial building codes | | | X | | X | X | | | |
| x. Expansion of existing tax incentives to solar heat | X | | X | | | | | | X |
| xi. Removal of RST from high energy efficiency windows | | | | | X | | | | X |
| xii. Solar pool initiative | | X | X | | X | | | X | X |
| xiii. Solar on government buildings | X | | | X | X | | X | | |
| xiv. Net Zero Energy Home Initiative | X | | | X | X | | X | X | X |

Note:
Technology
SHW – Solar Hot Water
SPH – Solar Pool Heating
SAV – Solar Air Ventilation
PV – Photovoltaic
PS – Passive Solar

Program Type
L – Legislation
M – Marketing
S – Support
T – Tax Changes

recommended for developing Ontario's solar sector, and greatly increasing the province's use of all solar technologies. These initiatives can also complement existing federal programs such as the Renewable Energy Deployment Initiative (REDI) of Natural Resources Canada.[63]

**i. Solar access legislation:** Although the use of PV and solar thermal systems is still rather limited, the time is fast approaching when these technologies will be within the reach of most households in Ontario. To maximize the use of these technologies, provincial and municipal governments should consider how to safeguard solar access for future use and for situations where new building construction obstructs an existing solar system (thereby reducing energy generation). These issues are critical to all solar technologies and can significantly improve the technical potential on new homes.

Currently, existing zoning and various covenants are instead creating barriers to the use of solar energy by putting restrictions on the few systems that can be installed on houses and other buildings. In a number of documented cases homeowners are now not allowed to install SDHW systems on roofs, and many municipalities ban the most basic of solar collectors – i.e. an outdoor clothesline.[64] The area of solar legislation and right to sun-light has lagged far behind the development of solar technologies.

The legal protection of solar access would be a first step in promoting an increased use of solar energy and would demonstrate government support for the technology.

**ii. Advanced Renewable Tariffs (REMs) – legislation and marketing:** A new provincial act or legislation setting up REMs should be introduced as soon as possible, to ensure large-scale renewable energy deployment in Ontario and to support the implementation of solar PV.

Participation in the REMs system will be influenced by a number of issues:

- Consumer awareness of REMs, and of financial and non-financial benefits of renewable energy;
- Technology availability and cost;
- Financing rates and terms;
- Ease of implementation;
- The incentive of REMs payments.

To maximize widespread provincial participation in REMs it will be necessary to have more than just legislation. Many of these issues can be addressed through good program design, education campaigns, and good marketing.

**iii. Solar ready: preparing homes for solar technologies:** Currently new residential housing units are not being built with their potential for solar being considered or designed for upgrading. By preparing a house during the construction phase for later solar energy use, there can be significant cost savings. As well, solar systems will be better incorporated and more aesthetically pleasing.

A "solar-ready" standard needs to be developed and marketed to builders with the intent of integrating it into the building code or high performance housing codes.

**iv. Solar financing: paying from solar savings:** While the Canadian market for solar technologies continues to expand faster than the use of conventional energy sources, having to pay for a solar system in one lump sum puts a damper on most consumers' purchasing enthusiasm, and also restricts the system size that people can afford.

Car dealers would sell few cars if customers were expected to pay the full sticker price in one payment. How can it be expected that a large number of consumers will buy a solar system without favourable financing? If solar is to be marketed effectively it must be financed by an agency, which, for tax and investment reasons, is prepared to take a ten-year investment horizon – thus effecting a lowering of monthly payments below the value of the monthly savings.

There are many international examples of solar financing programs. The German and Japanese solar roof programs provide valuable templates.[65] The aim of such initiatives is to simplify investment by individuals and small and medium companies and to bring the monthly payments of the solar system down below the monthly energy savings. In this case the payback on solar systems is immediate and the consumer payback acceptance curve approaches 100%.

Low interest loans at less than market rates reduce loan payments and generation costs. This incentive, already used in a number of countries, takes the form of an interest rate "buy down", which allows lenders to offer solar loans at a reduced interest rate and reduces the overall cost.[66]

The incentive applied as an interest rate subsidy is a small share of the total financing, with a lender having to provide most of the capital. Price distortion is minimal as the program subsidizes the financing cost and not the capital cost. The level of total incentive provided through an interest rate subsidy is much less than with other approaches and can overcome the major barrier of payback acceptance.

This financing mechanism can be carried out through a number of different agencies or financing models including solar banks, solar mortgages, solar leasing or solar energy service companies (ESCOs). Appropriate delivery agents would include utilities, conventional banks, and ESCOs.

However, because there is a lack of an existing example of this mechanism in Canada, it is unlikely that a private financing firm would undertake solar financing without an underwriting of the risks. Government could provide a "risk subsidy" in the range of 30–50% above standard interest rates to change this situation.[67]

A solar financing initiative run by a government agency would allow this mechanism to enter the market place and increase confidence in solar technologies. Solar financing would then slowly evolve onto a number of potential private financing agencies including utilities and banks.

**v. Solar certification and performance directory program:** A number of institutional barriers exist to the wider deployment of solar domestic hot water (SDHW) systems in Ontario. Many of these relate to a lack of codes, standards and guidelines, and to a lack of knowledge on the part of decision-makers. As a direct result, there have been recent examples in Canada where building permits have been denied for the installation of SDHW systems[68], homes in which SDHW systems have been installed are denied insurance coverage and insurance policies threatened to be cancelled, and water heater rental organizations have stated that they will void service contracts if a SDHW system is installed onto the customers' rented water heater.[69]

Before solar domestic hot water systems begin to be deployed on a large scale in Ontario these barriers must be removed. It is expected that there will be an updated CSA certification available for SDHW systems in place by the fall 2004. However the solar manufacturing firms in Canada are small and with the current low sales volume in Canada, it is not expected that many firms would submit their systems for testing and certification without government financial support.

**vi. PV early adopters program:** PV-generated electricity is not yet an economically viable alternative to conventional electrical generation – the payback for individual customers currently exceeds 25 years. Yet the PV industry in Canada is, each year, increasing its sales into the grid connected markets, and these sales cannot be explained by using a conventional payback acceptance curve. These sales in fact represent an "early adopter" market. While this market is small, it should be nurtured, as it is essential for public familiarization with the technology, and for industry to prepare for mass deployment in the future.

The program proposed would include:[70]

- PV systems to be installed over a 10-year period (1,000 per year);
- Systems that would average 3kW;
- Favourable REMs that would be guaranteed for 20-year period from date of installation;
- Program would last 20 years.

**vii. Expanding the 100% corporate income tax write-off for electrical generation:** Currently there is a proposed 100% provincial corporate income tax write-off for the cost of assets used to generate electricity from renewable energy sources. Solar heating is currently not eligible for the write-off. This write-off should be expanded to include renewables that generate heating and cooling.

**viii. Setting a minimum solar fraction in the building code:** Currently, while the Ontario Building Code mandates certain minimum levels of energy efficiency in house construction, it does not set standards for solar fraction. With the advent of simple computer simulations on home energy demands it is possible for builders to determine a building's solar fraction.

It is recommended that a minimum solar fraction for all new homes be set at 25% as a requirement in the Building Code.

**ix. Improve commercial building codes:** Commercial Building Codes should also be improved to include the requirements for on-site energy generation using PV and minimum fractions of solar thermal. There are no commercial building sites in Ontario that could not use active solar technologies if the building is designed and sited for solar use during the building design stage.

**x. Expansion of existing tax incentives to solar heat:** Currently there are a variety of tax incentives available, or being implemented, that are targeted for either residential renewable systems (electricity and heat) or corporations (for electricity produced from renewable energy sources). However, solar air ventilation systems are excluded. By expanding existing tax incentives to

include solar heat, the payback for systems will become more attractive for commercial energy consumers.

Currently there is an RST rebate for the purchase of qualifying building materials incorporated into commercial facilities to generate electricity from renewable energy or energy from deep lake water-cooling facilities. Commercial applications using solar heating are currently not eligible. By amending this limitation to include renewables that generate heat energy, the price difference between a solar air ventilation wall and a metal wall will be reduced to about 15% and would make the installation of solar air ventilation cheaper than a brick wall.

**xi. Removal of RST from high efficiency windows:** The principle of tax shifting has already been partially initiated in Ontario by the removal of retail sales tax (RST) from solar equipment and hybrid cars.

The principle of tax shifting should be expanded to include removal of RST on high efficiency windows (these windows can make a significant effect on lowering the heating needs of a home). Like other solar products the RST should be removed from solar windows to promote their contribution of energy to Ontario's energy mix.

**xii. Solar pool initiative:** Swimming pools are considered by many as a luxury item and the use of conventional energy sources such as electricity and natural gas for their heating entails environmental problems. Today there are more than 100,000 pools in Ontario that are heated using natural gas or electricity. Various jurisdictions in Europe and the U.S. have limited the used of conventional heaters for swimming pools.[71]

A combination of a 20% tax on pool heaters using a non-renewable energy source (natural gas and electricity) and a loan program with an interest rate subsidy for solar pool heaters would reduce the costs of solar systems to under a 2-year payback. Increased taxation on pool heaters using non-renewable energy sources would be in place permanently while the loan program (with five-year terms) could be in place for 10 years starting in 2005. It is estimated that the pool heater tax would raise $27 million over the 10-year period and these funds could be directed to fund solar programs around Ontario.

A long-term, local, focused marketing program is proposed that would run in conjunction with the proposed tax on pool heaters that use non-renewable sources. NRCan marketing in Vancouver, Niagara Falls, and Montreal illustrated their effectiveness.[72]

**xiii. Solar on government buildings:** This program would target the deployment of PV systems on government buildings and schools with the target of installing 100 kW per year on high profile buildings. The purpose is to expose architects and builders to the potential of using PV as a building material. BIPV can be cost-competitive much faster than rooftop PV as it displaces conventional building materials. If the cladding material it displaces is expensive (i.e. granite or architectural glass curtain walls) then PV can be competitive in a short timeframe.

**xiv. Net Zero Energy Home (NZEH) initiative:** By removing the GST and PST for a limited time from new NZEH homes, the cost of a NZEH would be equal to a conventional home.

The target would be to have all new homes built by 2030 to integrate on-site energy generation using PV, solar hot water, passive, and other technologies. The target by 2025 would be to have 40,000 new homes a year installed with SDHW.

## 4. Conclusions and further research

Ontario has a unique opportunity to take advantage of its solar resources for the generation of clean and reliable electricity and heat. Solar technologies allow the generation of electricity and heat unhindered by volatile fuel costs. They also represent a growing industry able to generate large numbers of good quality jobs.

Ontario could join leading jurisdictions in grid-connected PV by designing and enacting renewable energy mechanisms (REMs) to provide stable prices for electricity generated by PV systems and to ensure the right to interconnection of these systems to the province's grid.

REMs are a key policy strategy that needs to be complemented by a series of strategic solar initiatives (summarized in Table 24), which will enable the province to address effectively existing financial, education, and public awareness barriers currently hampering the deployment of solar technologies in Ontario.

It should be noted that many of the incentives identified for solar systems would not be needed if the environmental and public health costs of conventional energy sources were included in their price or if the current subsidies to the fossil fuel and nuclear sectors were phased out.

Further research is required to quantify and regularly update the environmental, social, and grid infrastructure costs of current forms of electricity generation. This is

an essential step to ensure more accurate price comparisons between distributed generation options, such as PV, and fossil fuel and nuclear-generated electricity. In addition, a detailed analysis of the total available surface to install solar systems (similar to that currently underway to map wind resources) needs to be commissioned to increase public awareness and to facilitate market participation.

### SOLAR PLANT A BOOST TO ONTARIO'S ECONOMY

A major solar cell manufacturing plant in southwestern Ontario is helping put Canada on the map as a leader in renewable energy.

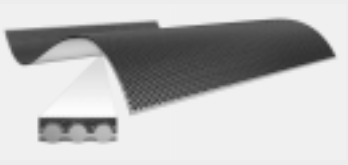
Cambridge, Ontario, is home to Canada's first full-scale solar cell manufacturing plant, which opened in June 2004. Automation Tooling Systems (ATS) expects its 193,000 square foot facility will soon will be producing revolutionary new photovoltaic technology in commercial quantities.

Not only will it expand Canada's presence in the global photovoltaic marketplace, the plant will also create 200 jobs and the investment of more than $100 million in the Canadian economy by the end of 2005.

Currently, the primary markets of this solar manufacturer are international. Changes in the public policy environment could establish significant domestic opportunities for this and other Ontario-based solar industries.

ATS expects its solar technology will accelerate the adoption of solar energy by consumer and commercial users – and open new mainstream applications because it can be manufactured cost-effectively. The resulting solar cells are pliable, lightweight, durable, and can be produced in a variety of colours that suit seamless integration with traditional building materials.

The solar cells use silicon to convert sunlight into electricity. This new technology incorporates thousands of tiny silicon spheres, bonded between thin flexible aluminum foil substrates to form solar cells. Developed in Canada using Canadian engineering and scientific expertise, the technology is considered to be major breakthrough for the estimated $3.4 billion global solar photovoltaic industry.



The Cambridge facility will produce 20 megawatts per year, capable of providing electricity for one year for 6,000 homes.

### CHICAGO: A GREEN LEADER

In 2001, the city of Chicago launched an aggressive campaign to make it the most environmentally friendly city in the world. In just three years, the city has become a clean energy leader by bringing renewable and efficient energy to government, homes and businesses.

Chicago set a goal to purchase 20 percent of its municipal power from renewable energy by 2006 – it has already reached 15 percent and expects to hit the 20 percent target two years ahead of schedule. Chicago is now one of the largest non-utility purchasers of renewable energy in the U.S. It expects to cut energy costs by a total of $260 million by 2010.

The city has also launched a program that provides various incentives to help city residents buy and improve historic bungalows. The program offers loans, energy conservation grants, free architectural assistance, and streamlined permits to anyone who purchases a bungalow for upgrading. In addition, the city supplies vouchers for energy-efficient appliances and matching grants for efficient windows, doors and insulation.

The city is supporting transformations to large manufacturers such as metal casters, chemical producers and sweets manufacturers. Each year, Chicago chooses one industry and helps it to improve energy use, prevent pollution and prosper economically. The goal is to achieve energy savings of 10 to 25 percent for each company.

### GERMAN CITY A SOLAR SUCCESS

Freiburg is considered the solar capital of Germany. Solar panels are commonly found on homes, hotels, sports arenas, schools, businesses and institutes in this city of 200,000 people.

Home to hundreds of environment-related companies, Freiburg is the envy of urban areas attempting to capitalize on the green energy boom.

Freiburg is host to *Solar Fabrik*, Germany's largest manufacturer of installation-ready solar modules. *Solar Fabrik* operates a zero emissions factory, Europe's first $CO_2$-neutral production facility for solar modules. The facility uses a combination of solar panels and solar design to achieve zero emissions.

Freiburg, a university city, is also home to Europe's largest solar energy research institute and Germany's first emission-free hotel.

## SOLAR CHAPTER NOTES

1 Although there are a few provincial studies that focus on specific solar technologies studies; for example see: Smiley, E. (2002). Green Energy Study for British Columbia Phase 2: Mainland Building Integrated Photovoltaic Solar and Small-Scale Wind. Burnaby: BCIT Technology Centre. Available at http://www.bchydro.com/rx_files/environment/environment3929.pdf

2 Chart supplied by Doug McClenahan, NRCan – presentation at CanSIA Forum – 2002.

3 Natural Resources Canada. (2000). A Buyer's Guide to Solar Water Heating Systems. Ottawa: NRCan. Available at www.canren.gc.ca/app/filerepository/AC5201041AFA42A1BFD51EA128F787CF.pdf

4 Ciorba, U., Pauli, F., Menna, P. (2004). Technical and economical analysis of an induced demand in the photovoltaic sector. *Energy Policy*, 32 (8), 949–960.

5 Maycock, P. (2004). PV market update. *Renewable Energy World*, 7 (4), 86–101.

6 Ibid (note that all decimal figures were rounded up).

7 Sawin, J.L. (2004). Mainstreaming Renewable Energy in the 21st Century. Washington DC: Worldwatch Institute. Available at www.worldwatch.org, also see Makower, J., Pernick, R., Friendly, A. (2003). *Solar Opportunity Assessment Report*. Washington, DC: Solar Catalyst Group. Available at www.solarcatalyst.com

8 Ibid. Sawin 2004.

9 Maycock (2004) op.cit. Note 5. These two key factors, guaranteed REMs for 20 years and long-term financing programs, have helped Germany to become a world leader in PV.

10 International Energy Agency Photovoltaic Power Systems Programme. (2002). *Trends in Photovoltaic Applications: Survey report of selected IEA countries between 1992 and 2002.* Available at www.iea-pvps.org

11 Weiss, W., Bergman, I. and Faninger, G. (2004) Solar Heating Worldwide: Markets and Contribution to Energy Supply. Gleisdorf, Austria: IEA Solar Heating & Cooling Programme. Available at www.iea-shc.org/welcome/welcome_page.htm

12 See Stryi-Hipp, G. Germany's case study in Weiss, W. (2004). Solar heating systems: status and recent developments. *Renewable Energy World*, 7 (4), 214–225.

13 Ibid. The act currently under design, known as the Regenerative Heating Act, would operate as Germany's Renewable Energy Act by placing a levy on conventional heating sources (primarily oil and gas), and use the proceeds from the levy to pay a premium for every kWh of heat generated by renewable sources.

14 Market demand for solar PV has been growing at a rate of 30–40% per year for the past five years and could approach 50% growth in 2004 through demand in the boom markets of Japan, Germany and since 2000 California for details see Eckhart, M. (2004). Growth Markets for PV: PV market outlook is bullish. *Renewable Energy World*, 7 (4), 191–195.

15 For more details about PV technology see www.iea-pvps.org

16 Peuser, K., Remmers, H., Schnauss, M. (2002). *Solar Thermal Systems: Successful Planning and Construction.* Berlin: Solarpraxis.

17 Natural Resources Canada. (1999). *Potential for Solar Heating of Outdoor Residential Pools to 2020.* Ottawa: NRCan.

18 For more details on hybrid systems see CANMET's hybrid info publications at http://cetc-varennes.nrcan.gc.ca/en/er_re/pva_sapv/p_p.html

19 Natural Resources Canada. (2002). *Renewable Energy in Canada: Status Report*. Ottawa: NRCan. Available at http://www2.nrcan.gc.ca/es/oerd/english/View.asp?x=700

20 See Islam, M., Fartaj, A. Ting, D. (2004). Current utilization and future prospects of emerging renewable energy applications in Canada. *Renewable and Sustainable Energy Reviews, 8 (6) 493–519*.

21 Personal communications with Xantrex, TDL, SSP, and Conserval, 2003–2004.

22 For more information on the job skills required for the renewable and details on the job areas directly connected to the solar industry see Peartree Solutions. (2003). *Situation Analysis of the Knowledge, Competencies, and Skill Requirements of Jobs in Renewable Energy Technologies in Canada.* Ottawa: Industry Canada.

23 According to Peartree Solutions (2003) employment estimates: PV industry = 1,000 jobs; solar water industry = 120 jobs; and solar air industry = 60 jobs. According to NRCan, the Canadian PV industry generated revenues of $100 million and employed approximately 615 people in 2003, for more details see Ayoub, J. and Dignard Bailey, L. (2003). *Photovoltaic Technology Status and Prospects: Canadian Annual Report 2003*. Ottawa: Natural Resources Canada. Available at http://cetc-varennes.nrcan.gc.ca/en/er_re/pva_sapv/p_p.html

24 Discussions with TDL, Enerworks, Solcan, Conserval in February, 2004

25 Industry Canada. (2003). *Unleashing the Potential of On-Grid PV in Canada: An Action Plan to make PV an integral Component of Canada's Energy Future*. Ottawa: Industry Canada. Available at www.cansia.ca/canreports.htm

26 The range of recent estimates of PV employment (per MW of PV) indicate: 82 jobs (from note 50); 35.5 jobs (*Clean Edge); 30 (*REEP); 184.6 (*CAL SEIA); 13–32 (*Massachusetts Institute of Technology); 36.6 (*Vermont) for units of measure and information for all aforementioned sources indicated by the sign * see Weissman, J. (2004). Interstate Renewable Energy Council Working Memo: Workforce Development Labor Forecasts & Job Trends for the Solar and Renewable Energy Industries. Latham, New York: Interstate Renewable Energy Council. Available at http://www.irecusa.org/ Also see Kammen,

D. Kapadia, K and Fripp, M. (2004). *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* Berkeley: University of California, Renewable and Appropriate Energy Laboratory. Available at http://ist-socrates.berkeley.edu/~rael/

27 Ayoub and Dignard Bailey (2003) op.cit note 23.

28 See Islam et al. (2004) op. cit. note 20.

29 For more details see NRCan's solar radiation atlas available at http://atlas.gc.ca/site/english/maps/archives/5thedition/environment/climate/mcr4076

30 PV Build Cool, www.pvcoolbuild.com, European Commission (under the 5th Framework, contract No. NNE5/2000/115) provides definitions of appropriate building surfaces which include:

- Flat Roofs: The definition of a flat roof used is a roof with an angle of between 0°–15°. These surfaces will require a support rack to maximize yearly energy production and
  proper liquid flow for active systems, and special measures need to be taken to insure watertight construction.
- Pitched Roofs: These are defined as roofs between 15°–75°. A support rack may be required in some applications to maximize energy production, however, this type of surface is the easiest to install on for small systems. Systems can be surface-mounted, integrated, or rack-mounted.
- Façades: A façade is defined as construction between 75°–115°. System types could include closed façade (curtain walls) that are not part of the main construction of the building but forms a protective skin on the outside (i.e. windows, see-through PV modules), and open façade (rain screens) that is an open system that is mounted to the front of the façade.

31 Based on data from: Natural Resources Canada. (2004). Energy Use Data Handbook 1990 to 2002. Available online at http://oee.nrcan.gc.ca/neud/dpa/home.cfm?PrintView=N&Text=N

32 Ibid.

33 See Housing Market Indicators, Ontario, 1990–2002 in Canadian Mortgage and Housing Corporation. (2003). Canadian Housing Observer. Ottawa: CMHC. Available at www.cmhc-schl.gc.ca/en/cahoob/index.cfm

34 See Natural Resources Canada (2004) op.cit. note 31.

35 EnerCity Guide – Draft; European Commission.

36 See Natural Resources Canada (2004) op.cit. note 31.

37 Estimate on energy production provided by John Hollick, Conserval Engineering, May 26, 2004.

38 The calculations presented here rely on the same methodology as a 1993 NRCan report (the most current on this topic), which estimated that 3.75% of air ventilation heating needs could technically be provided by SAV see NRCan (1993). *Solar Heating in Canada to the Year 2020.* Ottawa: NRCan.

39 Ontario, and most of Canada, had a body of common law in place to ensure homeowners' right to the sunlight falling on their property until the early 1900s when these laws were abolished due to pressure exerted by housing developers (see Planning Measures to Safeguard Solar Access for Buildings in Ottawa"; Discussion Paper CD164–6, City of Ottawa Community Development Department, 1981). In the U.S., many state solar access laws were enacted in the late 1970s. These laws usually include both covenant restrictions and solar easement provisions. The states' covenant restrictions prevent planning and zoning authorities from prohibiting or unreasonably restricting the use of solar energy. Solar access laws have been implemented in California, Colorado, Hawaii, Indiana, Massachusetts, Minnesota, Montana, Nebraska, Nevada, New Mexico, New York, Utah, Wisconsin, and Wyoming for more details see New Zealand Energy Efficiency & Conservation Authority & Solar Industries Association of New Zealand. (2002). Review of Overseas Initiatives that have been taken to Increase the Uptake of Solar Water Heating. Available at www.solarindustries.org.nz/documents/overseas_initiatives.pdf

40 See Natural Resources Canada (2004) op.cit. note 31.

41 See Natural Resources Canada (2000) op.cit. note 3.

42 Based on Natural Resources Canada (2004) op.cit. note 31.

43 See Natural Resources Canada (1999) op.cit note 17 – data prorated to 2001 which is being used here as the base year.

44 Natural Resources Canada. (1989). Passive Solar Potential in Commercial Buildings: Four Case Studies. Ottawa: NRCan.

45 Energy Research Group. (1994). Daylighting in Buildings. Dublin: School of Architecture, University College Dublin. Available at www.cordis.lu/opet/src/thrm029.htm

46 Referenced in Natural Resources Canada. (1993). *Active Solar Heating in Canada to the Year 2010*. Ottawa: NRCan.

47 The term 'innovators' is used to note a certain percentage of individuals will purchase a new product or technology regardless of the economics. These innovators currently account for a significant proportion of solar customers. There has not been a study done in Canada to determine the percentage of Canadians that could be considered potential innovators of solar – this is the current market for solar technologies until existing barriers are removed.

48 For more details about this innovative educational program see Renewable Energy Program of the Association of Canadian Community Colleges at www.accc.ca/english/services/renewable_energy_links.cfm

49 Projections supplied by Spheral Solar Products, May 2004.

50 See Winfield, M.S., Horne, M., McClenaghan, T. and Peters, R. (2004). *Power for the Future: Towards a Sustainable Electricity System for Ontario*. Calgary: Pembina Institute for Appropriate Development, and Canadian Environmental Law Association available at www.pembina.org

51 Personal communication with Enerworks and Thermo-Dynamics, May 2004.

52 See Natural Resources Canada (2004) op.cit. note 31.

53 See Maycock (2004) op.cit. note 5.

[54] For specific country figures see the system prices section of the International Energy Agency's Photovoltaic Power Systems Programme at www.oja-services.nl/iea-pvps/topics/i_costs.htm

[55] Eckhart (2004) op.cit note 14.

[56] See Sawin, J. (2004). *National Policy Instruments: Policy Lessons for the Advancement and Diffusion of Renewable Energy Technologies Around the World*. Bonn: Secretariat of the International Conference for Renewable Energies. Available at www.renewables2004.de/pdf/tbp/TBP03-policies.pdf

[57] Weiss and Faninger (2004) op.cit. note 11.

[58] Ibid.

[59] See Weiss and Faninger (2004, p.222) op.cit. note 11.

[60] Some of these issues have been previously analyzed in Pape, A. (1999). *Clean Power at Home*. Vancouver: The David Suzuki Foundation.

[61] Net Metering is usually understood as measuring the electricity used in a building versus the electricity generated using a renewable energy system. This calculation results in a 'net' energy total from which an electricity bill is calculated. Sawin (2004, p.6) op.cit note 56 observes that California and Texas did not achieve positive results from net metering for wind power or PV, and only achieved positive results until other incentives were added to the mix. Although her research indicates that net metering might have greater impact if private generators were to receive time-of-use rates for the electricity the generate the fact remains that feed-in laws have been successfully used to make countries such as Germany into world leaders in renewable energy technologies such as PV.

[62] For more information about a national initiative to develop and implement a Canadian guideline for the interconnection of small, distributed power sources see MicroPower Connect's web site at www.micropower-connect.org

[63] For more details about REDI see http://www2.nrcan.gc.ca/es/erb/erb/english/view.asp?x=455

[64] Discussions with Peter Sajko, Thermodynamics Ltd in May 2004 – situation in NS.

[65] See Sawin (2004) op. cit. note 56.

[66] New Zealand's government program provides subsidies for those customers who take out a loan for solar domestic water system and the subsidy is equal to the interest rate for the first year for more details see Solar Industries Association of New Zealand at www.solarin dustries.org.nz. In the US the states of California (SMUD), Idaho, Iowa, Nebraska, Oregon, Virginia, and Texas all have financing programs in place with low interest loans backed by the government or utilities (see NZ Energy Efficiency & Conservation Authority and NZ Solar Industries Association (2002). *Review of Overseas Initiatives that Have Been Taken to Increase the Uptake of Solar Water Heating*. Available at www.solarindustries.org.nz/info_solar.html#pub). India has over 100,000 such loans outstanding for solar water heating systems and this mechanism has now been introduced into the PV market and has already funded approximately 18,000 solar electric homes see Painuly, J. Usher, E. (2004). Got finance? A model to develop the PV market in South India. *Renewable Energy World*, 7 (1), 86–93.

[67] Canadian Solar Industries Association. (1983). *Third Party Financing of Solar Energy Systems – Phase 1 Report.* Ottawa: CanSIA.

[68] Presentation at the CanSIA 2003 forum, November 2003 – City of Ottawa is currently not allowing the installation of any solar DHW system which is not CSA certified however the testing procedure for the standard is not in place yet.

[69] Discussions with George Hay, May 2004

[70] A similar system is suggested by Rowlands, I. (in press). Envisaging feed-in tariffs for solar photovoltaic electricity: European lessons for Canada. Forthcoming in *Energy Policy*.

[71] Discussions with Joe Thwaites, Taylor Munro Energy, and Dan Takahashi, Enersol.

[72] NRCan ran small focused marketing programs in the early 2000s in Vancouver, Niagara Falls and Montreal, and there was a significant increase in public awareness in these regions. As the programs were extremely limited (one year long) and no monitoring of sales was done it is impossible to judge the success of the programs. However, industry members in the areas where the programs occurred have stated that it did have a positive impact on their sales over the following year (discussions with Joe Thwaites, Taylor Munro Energy Systems, May 2004).

# 7 Conclusion

**After years of neglect,** Ontario is in a unique position to transform its power system in a truly sustainable manner. Renewable energy and conservation will help protect the environment and public health while strengthening the economy, creating a brighter and better future for Ontario. Investing in renewable energy sources will give Ontario the most reliable electricity system, cost-effective power, cleaner air, and new jobs.

For example, in terms of jobs, if the renewable energy options summarized in Table 3 of the introduction are fully implemented by 2010, Ontario could have 25,000 people working in the renewable energy sector. By 2020 this sector could employ 77,000.[1]

The most sustainable path forward for Ontario is investment in energy efficiency, the creation of a conservation culture, and strong support for renewable energy.

Taking advantage of these opportunities will require effective policy decisions that: create stable demand for renewable energy technologies; ensure favourable access to the electricity grid at fair prices; facilitate low-cost financing; provide tax incentives; legislate standards; support education initiatives; and encourage active stakeholder participation.

Effective policies will also help ensure the province's renewable sources are tapped in a sustained and stable manner, positioning Ontario as a North American leader in renewable energy.

All forms of electricity in Ontario have been or are currently subsidized. The playing field, however, is very unequal. If direct and indirect subsidies to conventional sources of electricity were removed, and the immense environmental and public health costs associated with fossil fuel and nuclear energy were included, renewable energy would not require the degree of support outlined in this report. Even with the modest subsidies recommended, renewable energy is the most cost-effective, reliable, sustainable solution to Ontario's electricity crisis.

Currently, Ontario is relying on polluting coal-fired power plants and aging nuclear plants. It's an unsustainable combination – coal plants contribute to southern Ontario's poor air quality and summer smog, while nuclear plants are plagued with unresolved safety issues, chronic underperformance, and massive cost overruns. The large scale adoption of natural gas electricity plants is plagued with problems: dwindling domestic supply, price volatility and greenhouse gas emissions. Moreover, all of these centralized plants exacerbate the problems of Ontario's expensive and increasingly fragile transmission grid. Getting out of this crisis is not possible with the same type of thinking that led us into it.

Because of their distributed nature, renewable energy technologies offer the most reliable, stable, and cost effective options for new energy. It is time for Ontario's priorities to change.

So far, the province has set a modest goal to have 2,700 megawatts of renewable energy generation by 2010 (about 10 per cent of Ontario's current total installed capacity). *Smart Generation: Powering Ontario with Renewable Energy* shows that the province can achieve a much larger target.

*Smart Generation* urges Ontario's decision makers to develop five sources of renewable energy – wind, hydro-electricity, biomass, geothermal, and solar – while creating a strong focus on conservation and energy efficiency.

In light of the Ontario government's promise to shut down the province's coal-fired power plants by 2007, the need for sustainable alternatives has never been greater.

Confronting the serious public health consequences of coal-fired utilities creates an unparalleled opportunity to dramatically reduce the province's and the country's greenhouse gas emissions, addressing the most urgent crisis confronting humanity in the 21st century – climate change. Phasing out coal with conservation, efficiency, and renewable energy would reduce greenhouse gas emissions by about 38.4 megatonnes from 2000 levels.[2] This reduction represents 16 percent of Canada's Kyoto target.[3]

As illustrated throughout this report renewable energy options are already here and they are working with great success in countries as diverse as Germany, Spain, and Japan. Ontario has a lot of catching up to do. But it can be done.

Ontarians can continue to take the province down the unsustainable road of boosting supply by continuing to finance highly centralized, polluting and volatile sources such as natural gas or nuclear power, or can instead take a sharp turn towards investing in a healthier, reliable, and locally based electricity system.

Wind turbines, biomass and several other forms of renewable energy can create new sources of income for farmers and generate good quality jobs throughout Ontario, while providing a reliable local supply of energy.

## CONCLUSION NOTES

1 In this report it is estimated that the renewable energy sector could lead to the following employment creation:

- Wind: 100,000 person-years of cumulative employment by 2012
- Hydro: 240 jobs by 2020
- Biomass: 1472-6,181 jobs by 2010-2020
- GHP: 18,750 jobs by 2010 and 51,150 jobs by 2020
- Solar: 19,442 jobs by 2025

To calculate total employment by 2010 we converted the wind estimate of person-years to total jobs per MW by averaging this type of employment over the life of the wind facilities as described in page 6 of Kammen, D.M., Kapadia, K, and M. Fripp (2004) *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?* RAEL Report, University of California, Berkeley. Available at http://ist-socrates.berkeley.edu/~rael/renewables.jobs.pdf Following this approach, the person-years estimate is then divided by the average life of the wind facilities (i.e. 20 years) resulting in 5,000 jobs for 8,000 MW of wind turbines. For these calculations we are assuming that the estimated solar jobs will increase linearly from 2005 to 2025, i.e. 19,442/20=972 jobs per year; however, we do not include any solar jobs in the 2010 calculation to provide a more conservative estimate.

2 Stewart, K. (2003). Ontario and Kyoto. Ottawa: Climate Action Network. Available at www.climateactionnetwork.ca/resources.html

3 Canada's Kyoto commitment entails reducing annual greenhouse gas (GHG) emissions by 240 megatonnes (MT) see Government of Canada. (2003). *Climate Change Plan for Canada*. Available at www.climatechange.gc.ca./plan_for_canada/

# Appendix: Ontario Energy Profile

## Summary

Renewable energy can be used for the production of electricity, and for residential, commercial, and industrial building space conditioning (heating, cooling, and hot water). This appendix presents a brief overview of the demand for power and space conditioning in Ontario.

## 1. Present structure of Ontario's electricity sector

The past five years have been a period of extraordinary change and upheaval in Ontario's institutions and policies related to electricity. Competitive retail and wholesale electricity markets were introduced in May 2002. In response to public concerns over the sudden increases in electricity prices, the government terminated the competitive retail electricity market in November 2002, and introduced a fixed electricity *production* price of 4.3 cents/kWh. This fixed price was abandoned as of April 1, 2004 going to 4.7 cents/kWh for the first 750 kWh and 5.5 ¢/kWh for use above that level, a positive step to encourage conservation.

Ontario's total installed generation capacity is close to 30,000 megawatts (MW). The bulk of Ontario's installed power capacity is owned by Ontario Power generation (OPG). As of September 2003, OPG had a total in-service installed capacity of 22,733 MW (nuclear facilities = 6,103 MW; coal and oil powered stations = 9,700 MW; hydroelectric stations = 6,796 MW; low-impact hydroelectric facilities = 134 MW).[1] In addition, Bruce Power controls nuclear reactors with a total installed capacity of 6,660 MW.[2]

In 2003 Ontario's electricity demand totaled 152 terawatt-hours (TWh).[3]

The present fuel supply mix for electricity production is shown in Figure 1.

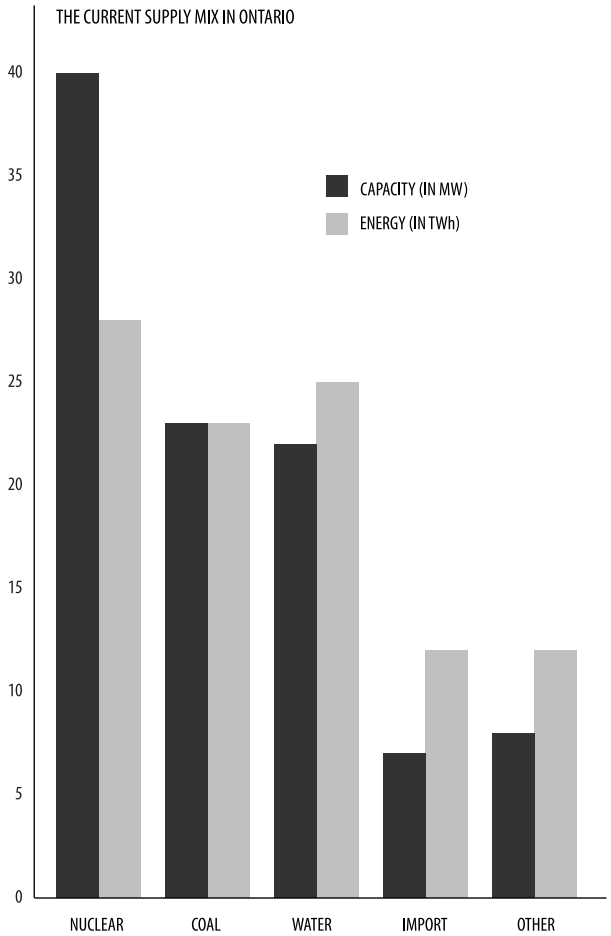



FIGURE 1 The current supply mix in Ontario[4]

### EXPECTED ELECTRICITY PRICE

The report *Power for the Future* shows an Ontario Electricity sales price forecast prepared by Natural Resources Canada.[5] The report authors consider these expectations reasonable for Ontario.

**TABLE 1**

Ontario's electricity sales price forecast (cents/kWh), 2000–2020[6]

| | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Commercial | 8.30 | 8.50 | 9.22 | 9.98 | 10.79 |
| Industrial | 6.30 | 5.38 | 5.83 | 6.31 | 6.82 |
| Residential | 10.00 | 10.24 | 11.11 | 12.03 | 13.00 |

While until April 1, 2004, the residential price *for production* was 4.3 cents per kWh, once other fixed and variable charges were added; the effective consumer price in Ontario is about 10 cents per kWh.[7] This price excludes the immense environmental and public health costs of the current energy mix, and it also does not include subsidies to nuclear and fossil power.

## 2. Heat demand

Contrary to electricity, heat cannot be transported at a long distance. The end-use and the location of the end user are important factors estimating the possibilities for renewable energy. In this section, the heat demand of relevant sectors is analysed with help of statistic information available from the Historical Database of Natural Resources Canada, Office of Energy Efficiency (available at http://oee1.nrcan.gc.ca/Neud/dpa/comprehensive_tables/)

### RESIDENTIAL SECTOR

Table 2 shows the secondary energy use of the 4.4 million households in Ontario. It is interesting to observe that space heating and water heating account for 58% and 21% of the domestic energy demand, respectively. The energy share of cooling is only 2.5% of the total energy demand, but will be an important factor during summer peaks of electricity use.

**TABLE 2**

Total secondary energy use in the residential sector in 2001 in Ontario, by energy source (PJ)[8]

| | Total Share | (%) | Space heating | Water heating | Space cooling | Other |
|---|---|---|---|---|---|---|
| Electricity | 159.9 | 31% | 34.7 | 22.5 | 13 | 89.7 |
| Natural gas | 302.3 | 59% | 216.1 | 83.8 | – | 2.4 |
| Heating oil | 29.1 | 6% | 26.8 | 2.3 | – | 0.0 |
| Propane | 4.1 | 1% | 3.4 | 0.6 | – | 0.1 |
| Other[a)] | 0.0 | 0% | 0.0 | 0.0 | – | 0.0 |
| Wood | 16.7 | 3% | 16.7 | 0.0 | – | 0.0 |
| **Total** | **512.1** | **100%** | **297.7** | **109.2** | **13** | **92.2** |

[a)] "Other" includes coal and steam

The possibility of using renewable energy systems depends on the type of building. Table 3 shows that most heat demand for space heating arises from single detached houses.

**TABLE 3**

Secondary energy use of space & water heating in the residential sector, by type of building (PJ)[9]

| | Space heating | Water heating |
|---|---|---|
| Single detached | 222.0 | 61.7 |
| Single attached | 36.0 | 16.5 |
| Apartments | 37.8 | 30.3 |
| Mobile homes | 2.0 | 0.8 |
| **Total** | **297.8** | **109.3** |

### COMMERCIAL AND INSTITUTIONAL SECTOR

The commercial and institutional sector consists of diverse types. Figure 2 shows that offices use 47% of the energy used in this sector. Public institutions, such as schools, are often suitable for renewable energy demonstration programs.

In Table 4 the division of energy demand into energy sources is shown. Natural gas is a major energy carrier, providing about 53% of the commercial and institutional energy demand.

As in the domestic sector, space heating is the dominant energy application with respect to final energy use (see Table 3).

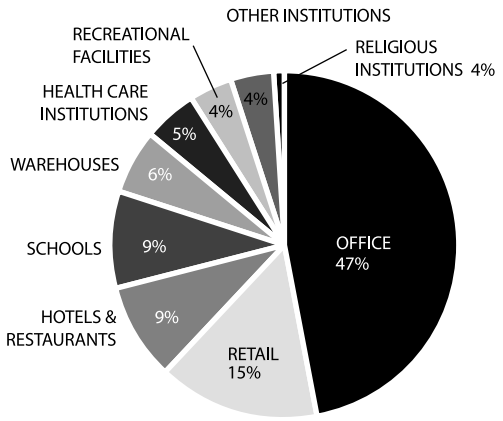



FIGURE 2 Total secondary energy use in the commercial and institutional sector by type of building (PJ) in Ontario (2001)[10]

**TABLE 4**

Secondary energy use in the commercial and institutional sector by energy source in Ontario in 2001 (PJ)[11]

| | Total | Offices | Schools |
|---|---|---|---|
| Electricity | 164.9 | 74.1 | 7.4 |
| Natural gas | 226.6 | 104.7 | 26.2 |
| Light fuel oil and kerosene | 17.2 | 8.0 | 2.0 |
| Heavy fuel oil | 7.5 | 3.7 | 0.6 |
| Propane | 7.5 | 3.7 | 0.9 |
| Other[a)] | 0.3 | 0.2 | 0.0 |
| **Total** | **424.0** | **194.4** | **37.1** |

[a)] "Other" includes coal and steam.

**TABLE 5**

Secondary energy use in the commercial and institutional sector by end use in Ontario in 2001 (PJ)[12]

| | Total | Offices | Schools |
|---|---|---|---|
| Space heating | 224.5 | 111.0 | 27.3 |
| Water heating | 24.8 | 5.1 | 2.5 |
| Auxiliary equipment | 34.4 | 17.8 | 0.6 |
| Auxiliary motors | 43.1 | 15.2 | 2.3 |
| Lighting | 61.7 | 32.0 | 3.2 |
| Space cooling | 33.0 | 13.4 | 1.2 |
| Street lighting | 2.6 | – | – |
| **Total** | **424.1** | **194.5** | **37.1** |

## 3. Price of heat

Natural gas is the dominant conventional energy source for heat applications. About 59% of the household energy demand is supplied by natural gas. Heating oil and propane provide 6% and 1% of the secondary energy demand in the residential sector, respectively, presumably at locations with no connection to the natural gas network, which creates an opportunity for renewable energy heating.

If pollution and health costs are totally ignored, natural gas is currently the cheapest option for heating but these prices are expected to rise in the future (see below). Heating oil (15.2 $/GJ) and propane (21.7 $/GJ) are more expensive. Heating with electricity is the most expensive The costs of heating equipment should also be taken into account.

At the wholesale level, natural gas supply prices throughout North America are determined by the dynamics of supply and demand. These prices fluctuate constantly. Short-term prices are particularly volatile owing to factors such as the weather, which can affect not only demand but also supply. It is observed that in 2003 prices of 7 $/GJ were paid for natural gas. In the longer-term, gas prices are affected by population and economic growth, the prices of substitutes such as fuel oil, and by environmental policies. For example, greater

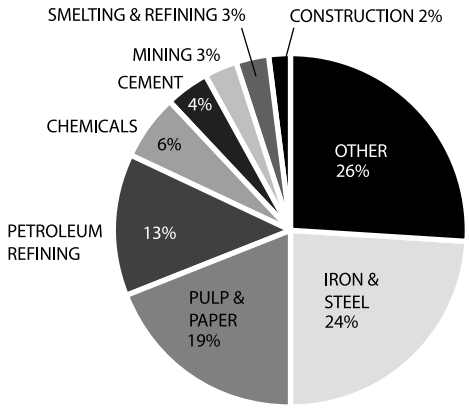



FIGURE 3 Secondary energy use in Ontario's industry by sub sector in 2001 (PJ)[13]

**TABLE 6**

Secondary energy use in Ontario's industry by energy source in 2001 (PJ)[14]

| | Total | Paper and pulp industry | Cement industry | Iron and steel industry |
|---|---|---|---|---|
| Electricity | 161.9 | 33.1 | 3.3 | 22.7 |
| Natural gas | 289.9 | 34.0 | 1.3 | 48.1 |
| Light fuel oil, diesel fuel oil and kerosene | 27.0 | 0.7 | 0.0 | 0.4 |
| Heavy fuel oil | 33.8 | 6.7 | 1.4 | 7.2 |
| Still gas and petroleum coke | 85.5 | 0.0 | 5.7 | 0.0 |
| LPG and gas plant NGL | 3.1 | 0.0 | 0.0 | 0.0 |
| Coal, coke and coke oven gas | 139.9 | 0.6 | 16.7 | 119.8 |
| Wood waste and pulping liquor | 83.0 | 83.0 | 0.0 | 0.0 |
| Other[a)] | 15.7 | 2.5 | 4.0 | 0.0 |
| **Total** | **839.8** | **160.6** | **32.4** | **198.2** |

[a)] "Other" includes steam and waste fuels.

demand for gas as a preferred fuel for electricity generation has resulted in higher gas prices.

The price that utilities have to pay for gas supply is determined in a competitive wholesale market. As long as the OEB is satisfied that the utility's purchasing strategy is appropriate, it is allowed to recover its gas costs by means of the supply charge billed to users who buy their gas supply from the utility.[15]

**TABLE 7**

Ontario's natural gas price forecast ($/GJ), 2000–2020[16]

| | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Commercial | 5.25 | 5.79 | 6.41 | 6.97 | 7.61 |
| Industrial | 3.61 | 3.97 | 4.40 | 4.76 | 5.18 |
| Residential | 6.37 | 7.01 | 7.76 | 8.46 | 9.25 |

The natural gas price forecast summarized in Table 7 shows steadily growing natural gas prices for all sectors.

## APPENDIX NOTES

1 See OPG "systems at a glance" at www.opg.com/ops/systems.asp OPG also owns wind-powered facilities totaling 2.4 MW see Canadian Wind Energy Association "Canada's installed capacity" at www.canwea.ca/en/CanadianWindFarms.html

2 For more details see Bruce A and Bruce B at www.candu.org/brucepower.html

3 See "demand overview" at www.theimo.com/imoweb/media/md_demand.asp

4 Source: Electricity Conservation & Supply Task Force. (2004). *Tough Choices, Addressing Ontario's Power Needs: Final Report to the Minister.* The report is available at www.energy.gov.on.ca/english/pdf/electricity/TaskForceReport.pdf

5 Analysis and Modelling Group. (2000). *Canada's Emissions Outlook: An Update*. Ottawa: National Climate Change Process.

6 Source: p.14 of Winfield, M.S., Horne, M., McClenaghan, T. and Peters, R. (2004). *Power for the Future: Towards a Sustainable Electricity System for Ontario*. Calgary: Pembina Institute for Appropriate Development and Canadian Environmental Law Association, available at www.pembina.org.

7 For more details see www.theimo.com/imoweb/siteShared/other_charges.asp?sid=ic.

8 Source: Natural Resources Canada, Office of Energy Efficiency available online at: http://oee1.nrcan.gc.ca/Neud/dpa/comprehensive_tables/

9 Ibid.

10 op.cit. note 8.

11 op.cit. note 8.

12 op.cit. note 8.

13 op.cit. note 8.

14 op.cit. note 8.

15 The Ontario Energy Board (OEB) sets the rates that Enbridge Consumers Gas, Union Gas and Natural Resource Gas can charge for selling, distributing, transporting and storing gas.

16 Source: p.14 of Winfield et al. (2004), op.cit. note 6.

# Glossary of Key Terms

**BASE LOAD** The minimum continuous load over a period time.

**CAPACITY** The maximum continuous power output of a given generating facility. Individual generator or station capacity is commonly rated in kilowatts (kW) or megawatts (MW).

**CAPACITY CREDIT** The capacity rating multiplied by an "availability factor" which reflects the availability of the generating source to be on-line when required. The capacity credit is a measure of the amount of dependable, dispatchable capacity that a system operator can rely on from an individual generating station.

**CAPACITY FACTOR** The ratio of actual expected energy production to total potential energy production, given the nameplate rating of a power plant.

**CAPACITY RATING** The nameplate (maximum) capacity of a generating source multiplied by the average time the generating source is available to generate power. For renewable energy generators such as wind turbines, the capacity rating is primarily determined by the wind resource available in a given area.

**CONSERVATION (OF ENERGY)** Any activity, program or technology that reduces the amount of energy consumed. Turning off lights when leaving a room or installing a high-efficiency appliance which consumes less energy than the unit it replaces are examples of conservation.

**DEMAND SIDE MANAGEMENT** Any action or program that reduces current uses of energy.

**DISPATCHABLE GENERATION** An electrical generation source that is capable of automatically, or through remote control, adjusting its output in response to real-time load conditions of the grid.

**ENERGY EFFICIENCY** The amount of energy used by an apparatus or process to complete a given task.

**GIGAWATT-HOUR (GWH)** Power unit equal to one million kilowatt-hours. In 2003 Ontario's electricity demand was approximately 416 GWh per day.

**GRID (DISTRIBUTION)** A network of medium and low-voltage power lines interconnecting the grid transmission system with industrial, commercial and residential load customers.

**GRID (TRANSMISSION)** A network of high-voltage, long-distance power lines interconnecting generating facilities with distant electrical distribution systems.

**HEADPOND** The upstream catchment area or run-of-river water feed supplying the hydropower station. Head refers to the vertical drop through which water must fall before expending its energy on the turbine blades. A comparison of similar sites, with one having higher head will produce more energy. A hydropower site with water storage in the catchment area can produce peak energy at a rate higher than can be supplied by water inflows. A run-of-river site can generate peak energy equal to the maximum instantaneous inflow of water.

**HERITAGE GENERATING ASSETS** Government-owned power generating assets which are sufficiently old as to have their capital costs depreciated to zero. Heritage generating assets produce electrical power at the lowest rates, which skews public perception when comparing energy costs of new, capital intensive facilities.

**I.M.O.** The (Ontario) Independent Electricity Market Operator is a non-profit, regulated corporation established by the electricity act that sets forth terms and operating conditions of the wholesale

electricity market and management of the high-voltage transmission grid. The IMO is expected to be replaced through new legislation.

**INTERMITTENT POWER SOURCE** An electrical generation unit whose output changes due to variability of the input energy source.

**KILOWATT (KW)** 1,000 watts of power. The capacity of a small kettle, iron or hairdryer.

**KILOWATT-HOUR (KWH)** The amount of electrical energy produced or consumed when one kilowatt of power is used for one hour. For example, ten 100-watt light bulbs burning for one hour would consume one KWh of energy.

**LOSSES (TRANSMISSION SYSTEM)** The energy that is lost as heat due to electrical resistance in a given length of transmission system. In Ontario approximately 8% of all electricity generated is lost due to transmission system resistance.

**LOAD** The amount of electrical power that is instantaneously required at any given part of the electrical system.

**MEGAWATT (MW)** Power unit equal to one million watts. Current wind turbines range in size from ~1–5 MW each.

**MEGAWATT-HOUR** The amount of energy produced or used when one megawatt of power is consumed for one hour. As energy is the product of power and time, one megawatt-hour of energy would also be produced if a generating station were to deliver 500 kWh for two hours.

**OFF-PEAK PERIOD** The period of time (whether considered daily, seasonally or yearly) when energy use is below its maximum level.

**PEAK-USE PERIOD** The opposite of off-peak period.

**PEAKING CAPACITY** An electrical generator that is typically used only to meet the energy requirements of peak or high-demand periods. Peak generation is normally provided by hydroelectric or gas turbine generators.

**PETAJOULE** A petajoule (PJ) is equivalent to $10^{15}$ joules. The joule is the official standard unit of energy. 1 million tonnes of coal equivalent = approximately 28 PJ (assuming 100% conversion efficiency), and 7.3 million barrels of oil = approximately 42 PJ (assuming 100% conversion efficiency).

**WHEELING** The act of transmitting blocks of energy on the high-voltage transmission system between a generation source and load.

Ontario is at a critical energy crossroads. The province's decision makers are about to choose how Ontario will produce and use electricity in the coming decades.

The choices they make will profoundly affect all Ontarians. They can either take the province down the same road of boosting supply to meet increasing demand or forge a new path towards a more sustainable electricity system with renewable energy and conservation.

*Smart Generation: Powering Ontario With Renewable Energy*, urges Ontario's decision makers to develop the province's abundant renewable sources of energy while creating a new focus on conservation. In return, Ontario will get a more reliable, cost-effective electricity system, cleaner air, more jobs, and the development of a new and vibrant economic engine.

*Smart Generation* summarizes the potential of five sources of renewable energy for Ontario: wind, hydropower, biomass, geothermal and solar. It also makes key policy recommendations on how to rebuild the province's power system with these sources of energy.

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Good morning,

I encourage you to endorse a future Ontario energy mix with at least 60% emphasis on renewables. Coal is dirty, creates smog and contributes to global warming. Nuclear is a giant financial sinkhole which never meets its budget or time frame objectives. Let's aim for high efficiency gas plants, hydro, wind and other renewables to keep the lights on.

Regards,

Roger Dibben
East York

We would like support the OPA to include a scenario with a minimum of 60% renewable electricity by 2020 and a full phase-out of dirty coal and unreliable nuclear power through different mixes of various power sources and conservation measures.

Sincerely
Marjut Dunker

I am pleased to respond for your call for written submissions. I previously made these views known to the Premier of Ontario and Minister of Energy.

Firstly, I suggest your outlook of 20 years is much too short-sighted. A 50-year or 100-year plan is necessary. The long planning and construction timeframes, combined with 30-50 years of service from power generators requires a very long outlook.

Power generation on the scale required in Ontario demands very large facilities. I hope **Nuclear Power** will be considered for new facilities. Compared to the other practical means of baseload supply (hydro, gas, oil or coal) nuclear power is by far the least destructive in terms of the environment, watersheds and natural resources. Environmentalists have railroaded the nuclear power option. Please listen to the scientists and engineers on both sides of the argument, and ignore the radicals. The amount of waste from a nuclear power plant is easily managed. The CANDU reactor is also the safest reactor on the planet, operating a relatively low temperature and pressure, with a low-toxicity fuel, compared to other designs in use around the globe. The CANDU reactor on offer today is much improved over the ones last built in Canada.

The per-kilowatt-hour cost of nuclear power is very competitive. That the debt assumed during construction was poorly managed is not a reflection on the technology, but on the administration of the day.

One of the promises made in the last election campaign was to close Ontario's coal-fired power generators. I applaud this. We don't need to add air pollution or CO2 to the environment. But, replacing coal generation with natural gas generation does very little to reduce CO2 emissions while hastening depletion of natural gas reserves - a non-renewable resource.

At the same time, solar and wind power have a place in small, distributed power generation in remote communities. As the cost, efficiency and scale of these generators makes them more practical, they can make a greater contribution to the power requirements of Ontario.

sincerely,
Lawrence Dunning
Brockville, Ontario